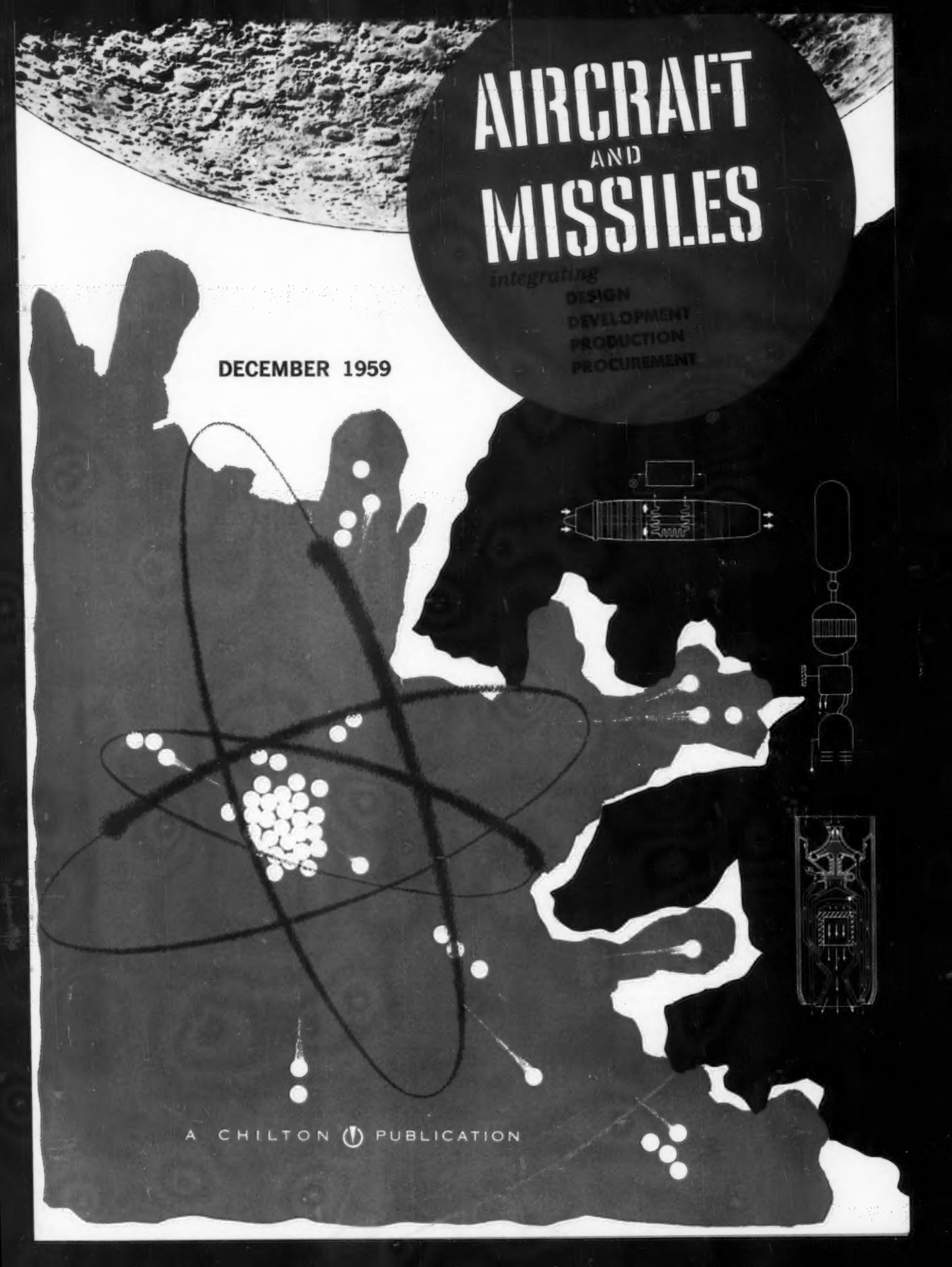
AIRCRAFT AND MISSILES

integrating

DESIGN
DEVELOPMENT
PRODUCTION
PROCUREMENT

DECEMBER 1959



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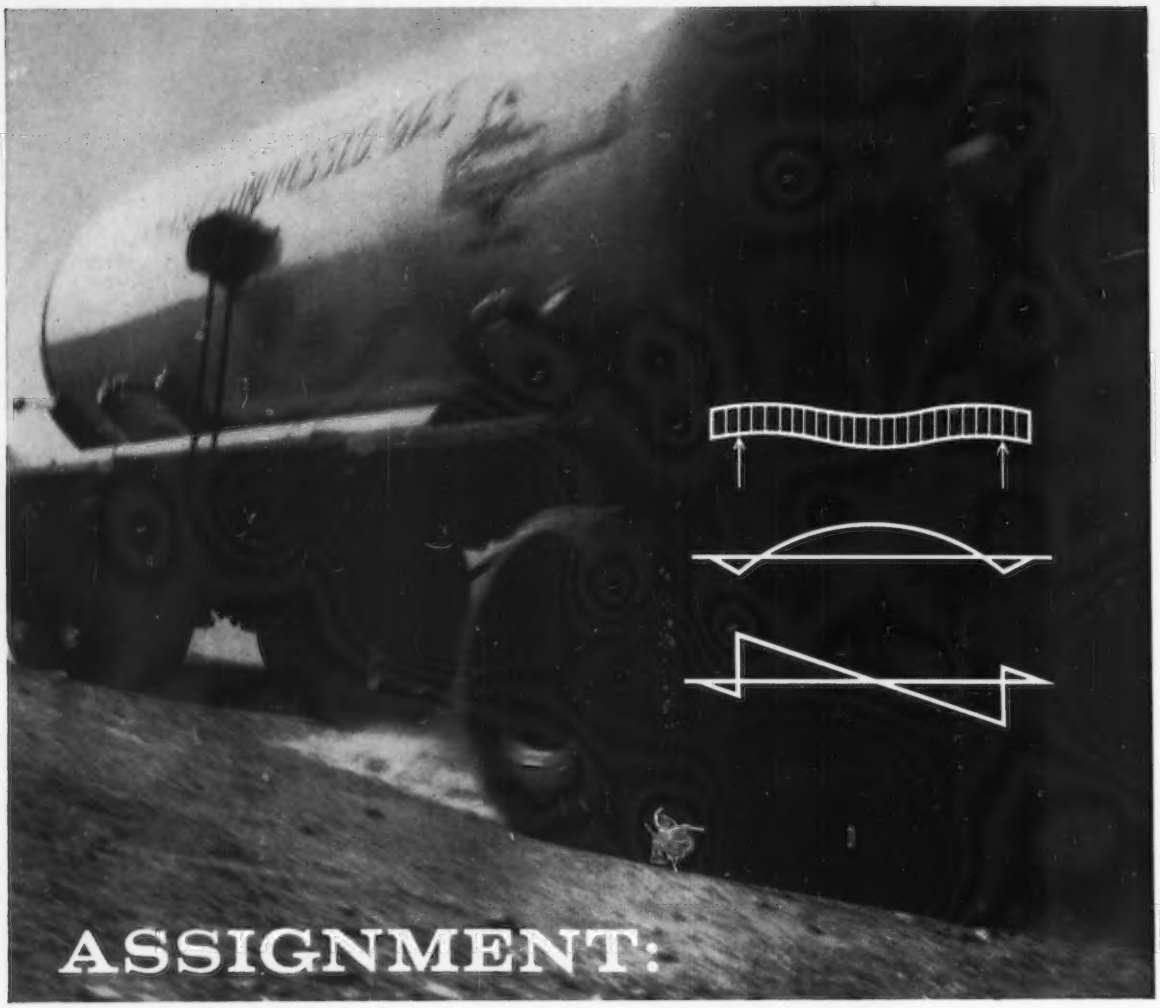

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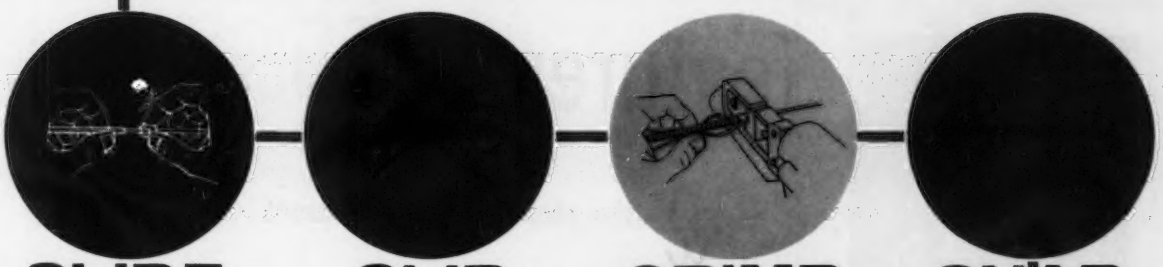

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AIRCRAFT AND MISSILES

DESIGN • DEVELOPMENT • PRODUCTION • PROCUREMENT

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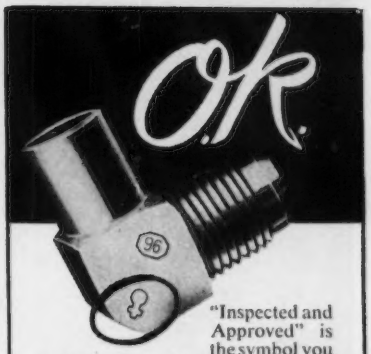

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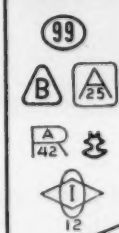

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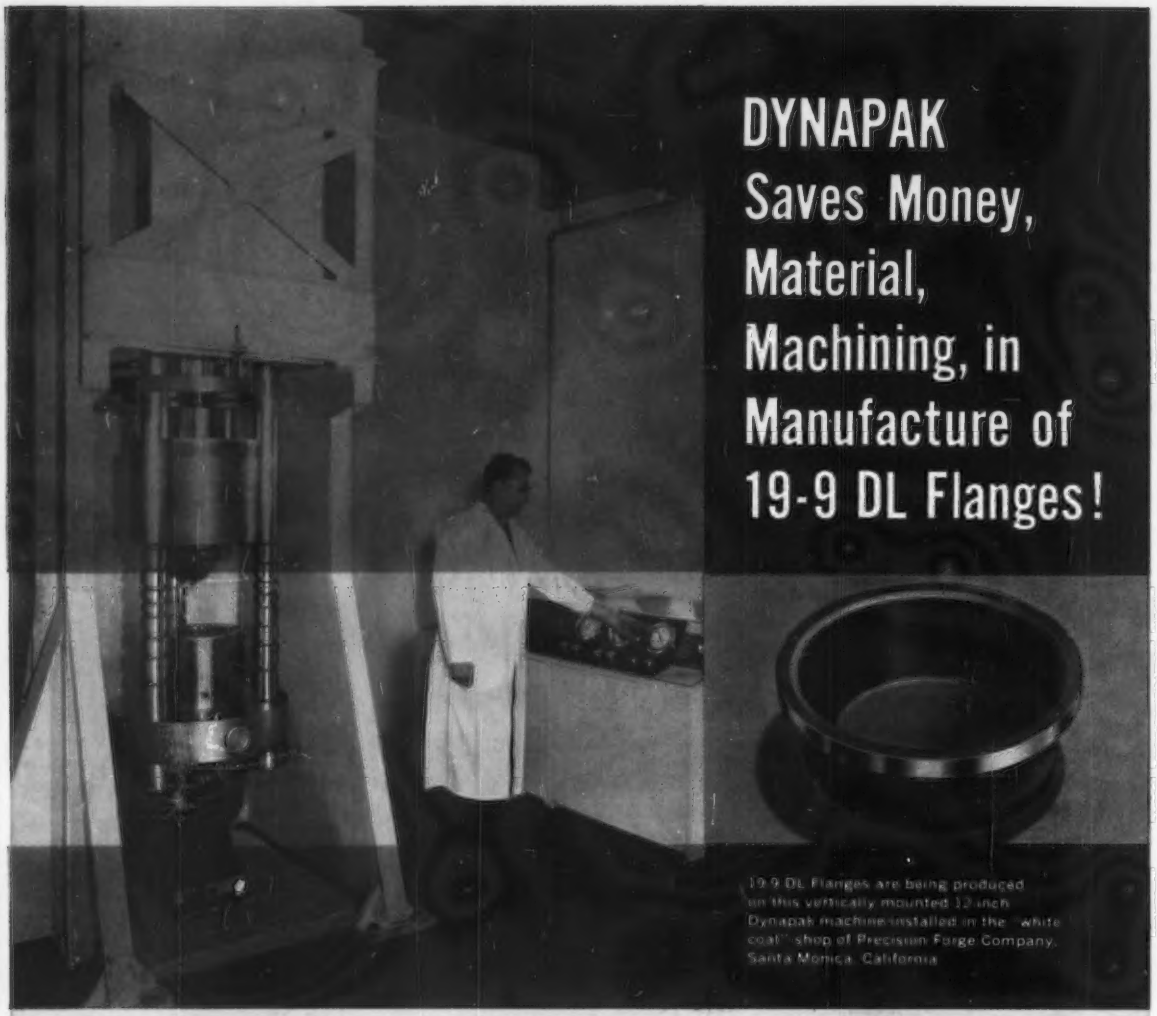

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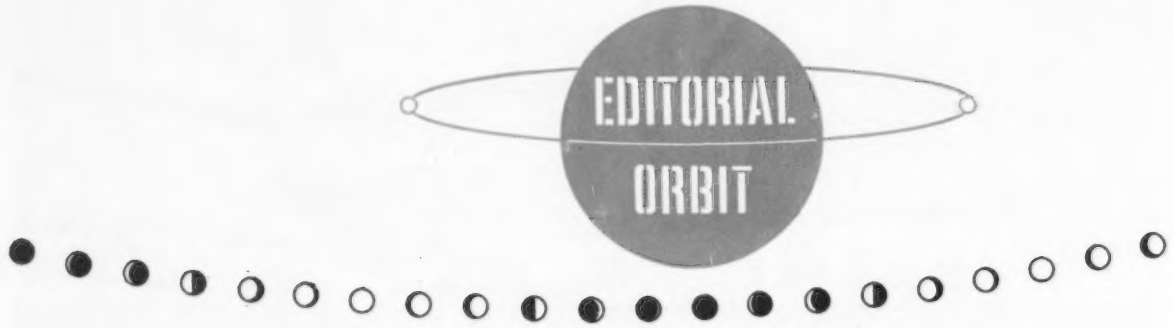

you can't score without a goal

So we're going to fly a nuclear-powered aircraft! But, don't count your projects before they're supported.

Big advances have been made in technology of both direct and indirect cycle nuclear powerplants. Yes, the experts agree that a propulsion system could be built today to put a nuclear plane in the air. What's the delay? Early flight is being held up by the search for more "advanced" materials. Optimistically, the research people indicate that this problem can be licked soon, too. Then, what is the real problem? Certainly not a lack of technical knowledge, but the lack of a well defined goal and proper funding.

Let's take a glance back over the 13 years since the Aircraft Nuclear Propulsion program got underway.

In March 1948, the Congressional Aviation Policy Board urged the ANP program be accorded "the highest priority in atomic energy research and development." In March of '51, General Vandenburg, Air Force chief of staff, urged AEC to give the project high priority. Yet, two years later, the National Security Council ordered the program cancelled. The reasons—budget, and because the program was *not* deemed in the national interest.

The Joint Committee on Atomic Energy, taking its familiar role of fact-finder in the opinion clash, helped keep the program going. But, in December 1956, with AEC and DOD again pushing an all-out effort, the program was reduced by the budget.

It has been an off-again, on-again project, highly-classified, attacked as a "shitepoke," then upheld as a necessity, paid for with over $900 million in 13 years, but without a target date, undergoing metamorphoses without a well defined tactical concept.

Since scientific advice is now more a part of our planning, maybe definite targets will be established. Yet, it is deplorable that we still proceed half-fundedly in many projects of national interest.

Tom MacNew
Editor

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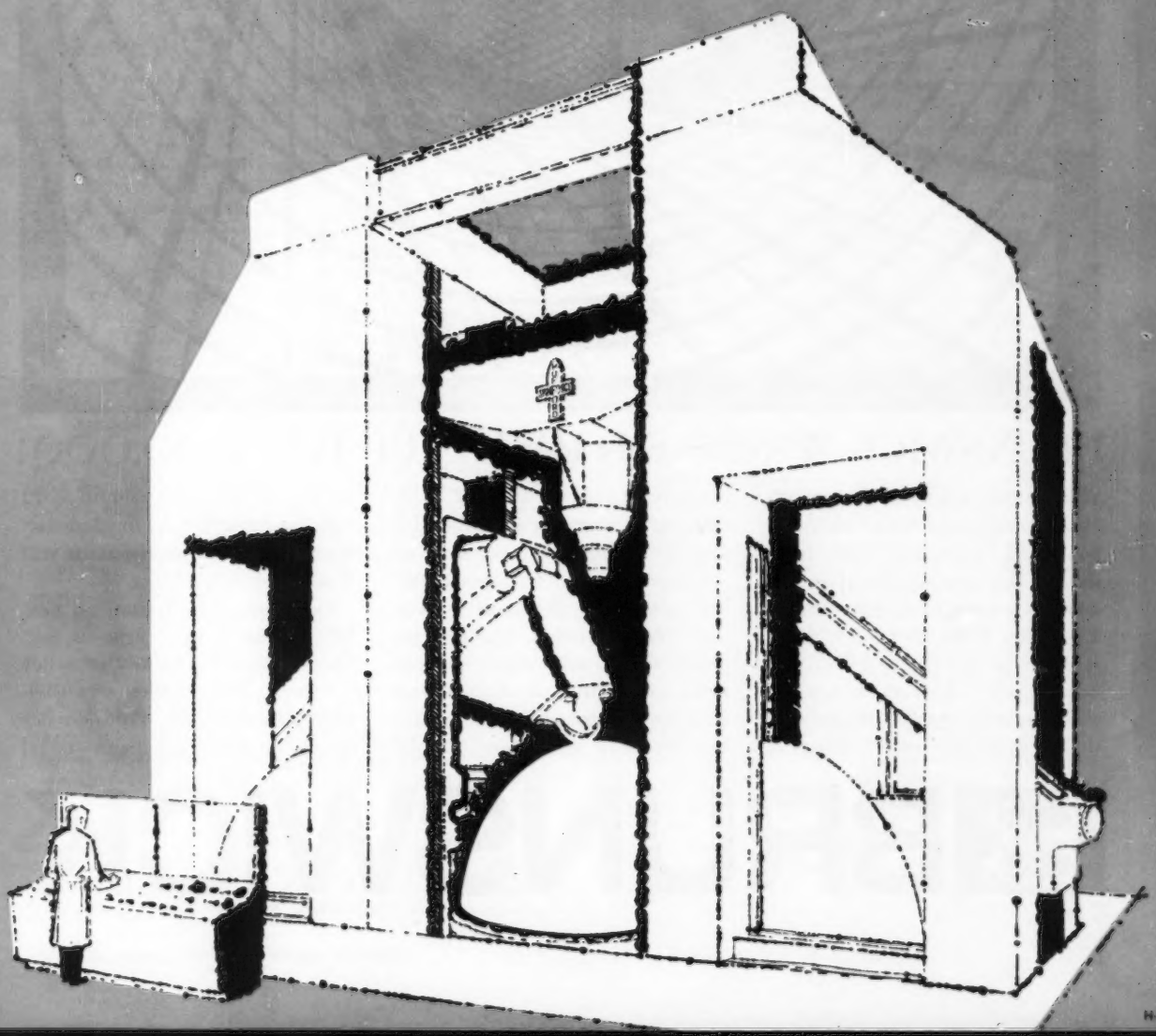

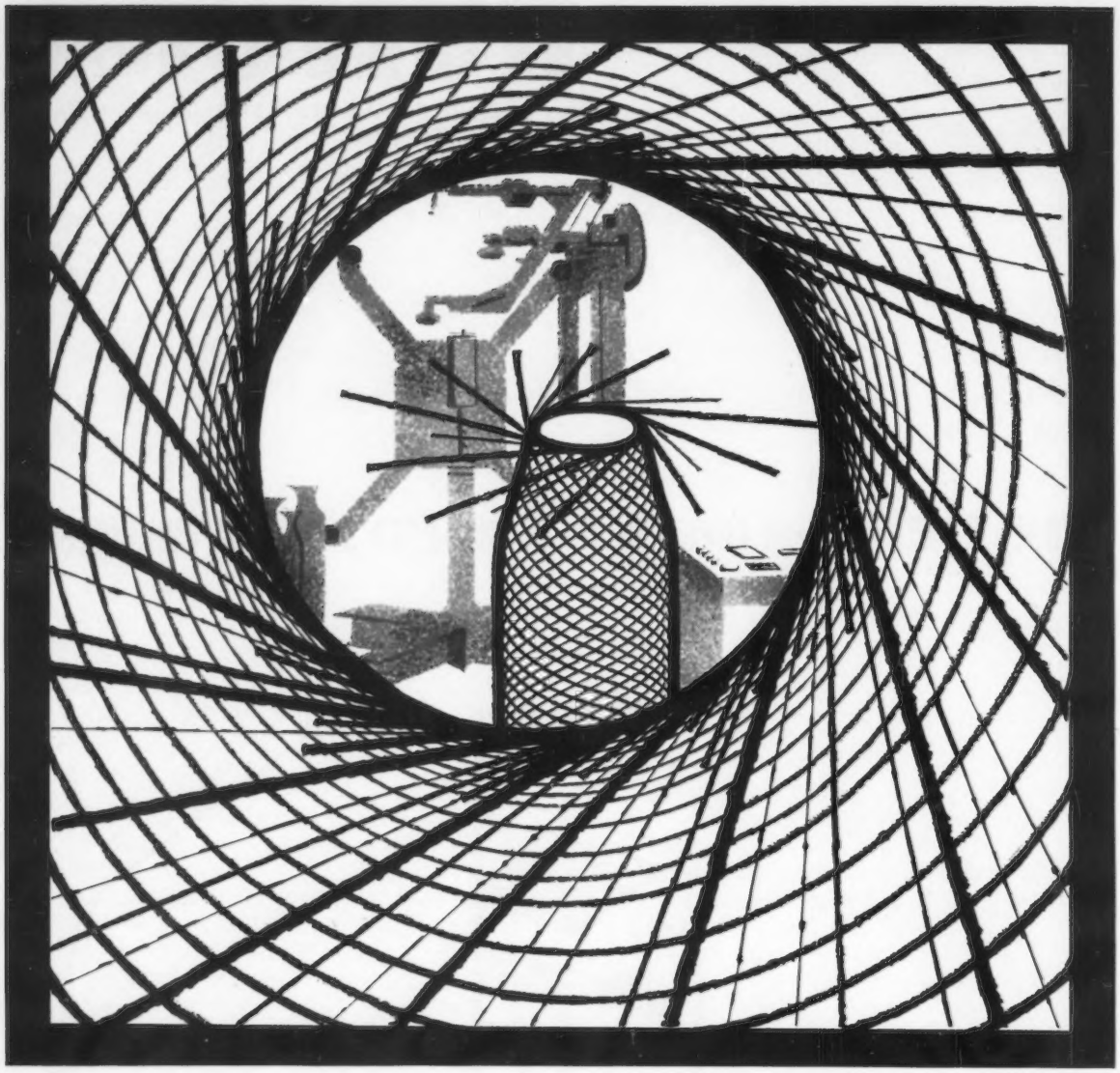

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BRUNSWICK

MAKES YOUR IDEAS *WORK*

AIRCRAFT AND MISSILES industry orbit

AIRCRAFT

DESIGN

Steel pylons which are structural members of B-58 wings weigh about 900 lb, are 96 in. long . . . B. F. Goodrich Aviation Products reports its new wheel and brake system for the B-70 is "far in advance of any now used on modern aircraft" . . . **Hughes Aircraft is considering development of future remote-controlled Mobot Mark I manipulators to service nuclear-powered aircraft** . . . Sikorsky has designed rear-loading version of HSS-2 twin turbine helicopter.

DEVELOPMENT

The Joint Congressional Atomic Energy Committee has suggested the nuclear aircraft program be handed over to AEC instead of joint AEC-Defense Department control . . . **Two G. E. CJ-805-3 commercial turbojets are past 1000 hours of flight testing on a leased RB-66. Aft-fan configuration, the CJ-805-23, will be tested after RB66 is modified to take Convair 600 pods** . . . Test program for a pre-compressor cooling (water) system for J85 turbojets begins this month; joint Northrop-G.E. team has been testing advanced thrust augmentation system for engine used in N-156F Freedom Fighters now in flight evaluation . . . **Sperry Gyroscope has unveiled prototype of 120 lb AN/APN-118 radar navigator and flight instrumentation system developed with cooperation of Army Signal Research and Development Lab. Nine-inch-square map display shows aircraft's position and progress** . . . Automatic pilot with solid state electronic circuiting replacing moving parts is being developed by Bendix Aviation Corp. . . . Navy Bureau of Weapons reportedly has sent requests for proposals on new or converted aircraft for its Eagle missile to airframe and engine manufacturers. . . . Dyna Soar's front end "aircraft" section has propulsion section which is still under development . . . Naval Air Development Center is studying a nuclear engine for aircraft.

PRODUCTION

Volume HU2K helicopter production begins in early 1960 at Bloomfield, Conn. . . . **Sierracin Corp. windshields for Douglas DC-3 and Lockheed 18 and PV-1 are now FAA certified. Electric current through thin metallized coating on windshield produces anti-fogging and de-icing effects** . . . All weather F-105D's are now on the production line at Republic . . . Saab delivers 13 more 91D Safirs to the Dutch civil flying school shortly; five of the 18 on order were delivered this Fall . . . **Boeing is running an underground air conditioning and heating system which is hooked up to B-52 G's integral wings. This maintains 72°F for sealant crews inside the 80 ft sections.**

PROCUREMENT

Scandinavian Airlines is purchasing two more Convair 600 jets, making four to be delivered to SAS in Spring of 1961. The Navy reportedly indicated some 250 Kaman HU2K helicopters may eventually be ordered for fleet operations . . . Republic's backlog of orders stood at $500-million on Sept. 30 . . . **General Mills bought number two production model of L. B. Smith's "Tempo II"; delivery in early Spring . . . Saab Aircraft has delivered first five 91D Safirs to the Dutch government civil flying school, delivers 13 more shortly** . . . First five Vertol 107 helicopters may be purchased by New York Airways under recently-concluded option agreement . . . Dutch Navy receives 12 Grumman S2F Tracker ASW aircraft shortly . . . **The Pentagon denied North American's request to assume major B-70 subcontracts** . . . Canadian Pacific ordered four DC-8 jets from Douglas, with options for five more . . . 98 Convair B-58 Hustlers are on order for the Air Force . . . Seven Convair 880's will be delivered to Capital Airlines in October 1960.

MISSILES

DESIGN

Minneapolis-Honeywell Regulator Co. design-study of self-adaptive space vehicle flight control systems may result in system being flight-tested in the X-15. Major problem is transition from use of aerodynamic surfaces to "pure reaction control" in space . . . **Dr. B. D. Thomas, president of Battelle Memorial Institute, recently told industrial designers that "the development of steel with a strength of 400,000 psi should not be considered impossible"** . . . Corvus warhead safety and arming device, under development by Bulova Research & Development Laboratories for over a year, features "resettability" concept permitting complete test cycling in the laboratory . . . **Bulova is designing a subminiature control attenuation timer for ABMA use in telemetering equipment (timing motor is smaller than a one-inch cube) and the nuclear warhead adaption kit for Pershing.**

DEVELOPMENT

Army Ordnance Missile Command's public information office declares fabrication of the Saturn superbooster continues on schedule at the Army Ballistic Missile Agency. Von Braun team working on the NASA project recommends raising Saturn's budget to $240-million in 1960 from present $70-million. First static test is scheduled for this Spring . . . **Rocketdyne's 1,500,000-pound-thrust "F-1" single-chamber engine is expected to be completed in four or five years. Construction of the Nova vehicle employing six F-1's may take an additional two or three years** . . . B. F. Goodrich is developing a new high thrust solid fuel in Rialto, Calif. . . . **Initial flight tests of Arma's all-inertial guidance system in Atlas take place next year** . . . General Electric's Nuclear Emulsion Recovery Vehicle (NERV), under development at MSVD, will be boosted to 1800 miles by an ARGO D-8 rocket next year to measure the Van Allen radiation belts . . . **Navy consolidation of the Bureaus of Ordnance and Aeronautics into the new Bureau of Naval Weapons is effective Dec. 1** . . . Allis-Chalmers and AiResearch

continued on page 79

what's holding back

the atom powered aircraft

lack of funds and objectives cited, search for "advanced" materials governs DOD thinking—delays early flight

by John P. Kushnerick

Aircraft nuclear propulsion program (ANP) has been under way for 13 years. About $900 million has been spent; roughly $650 million of this has been directed to propulsion studies, the remainder has been spent on airframe, shielding, and related areas. No nuclear aircraft has resulted, and most experts agree that one could not be put into the air for about 3 years, even if the go ahead were given today. This is unlikely, because a decision has not yet been reached on what kind of nuclear plane we want, or exactly what we want it to do. What is worse, none of the agencies now studying ANP has the authority to make this decision.

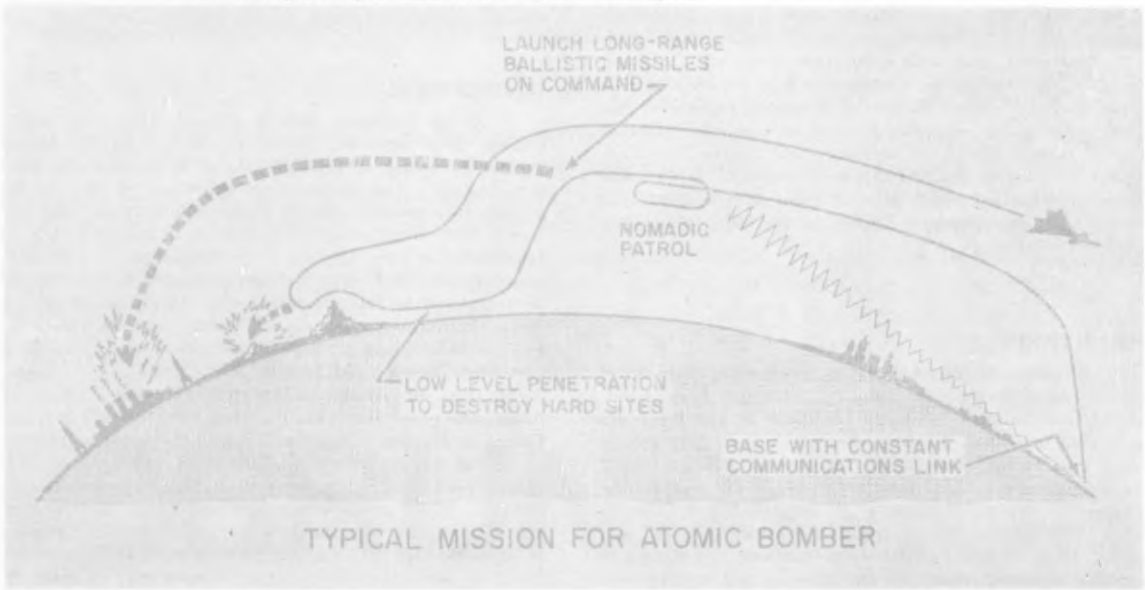
Two Different Approaches

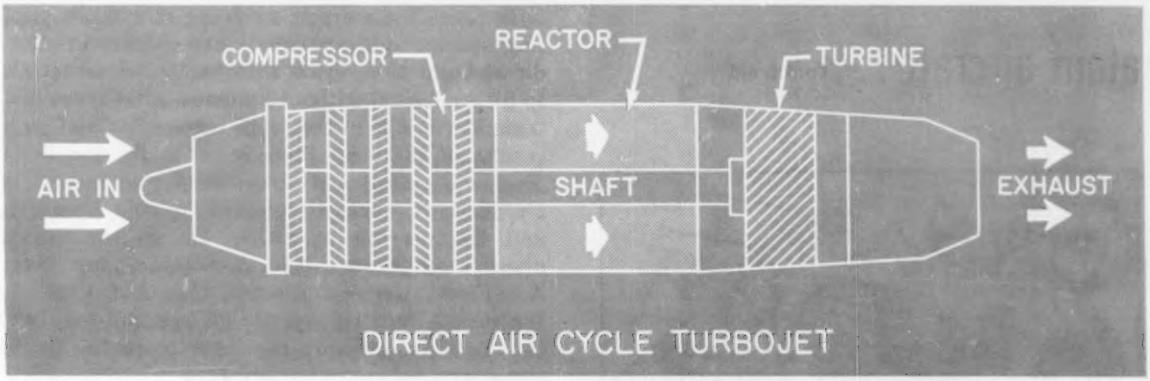
Two different approaches have been generated to date on a nuclear powerplant for aircraft.

- The direct air cycle.
- The indirect air cycle.

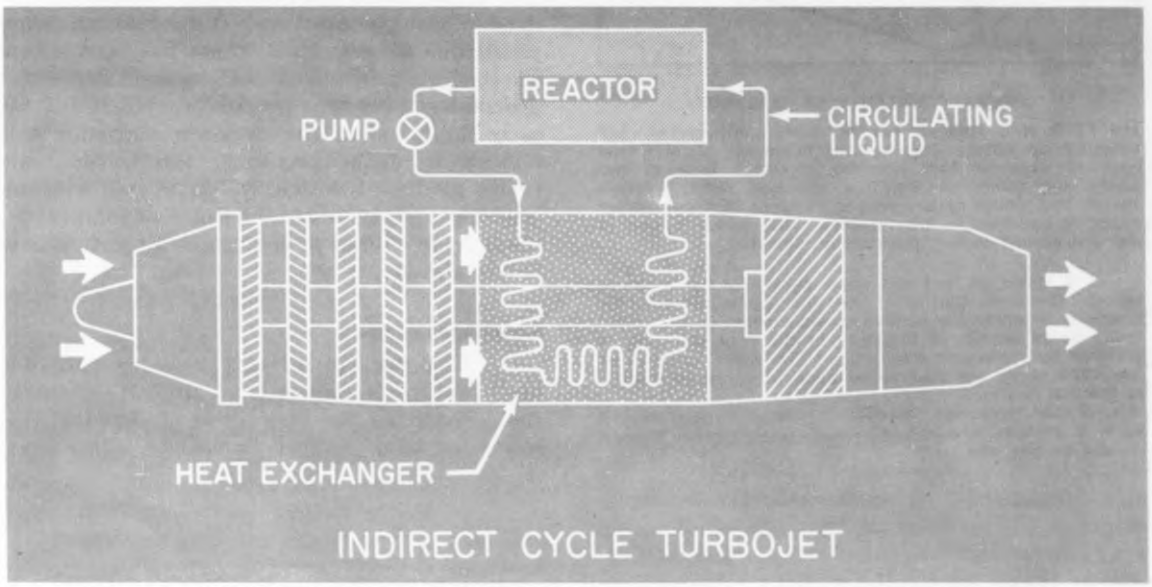
Direct-air-cycle system is being pursued by General Electric Co. and Air Force. In this system, the air which drives the propulsion system is passed directly over the reactor core to raise the temperature. In the indirect system, being developed by Pratt & Whitney with both Navy and Air Force backing, a liquid is circulated through the reactor and then through an air radiator. The air is brought up to temperature for propul-

CAMAL system (Continuous Airborne Missile Launching and Low Level Penetration) lays some general requirements for nuclear aircraft. Such an aircraft cannot be built with presently available materials and techniques.


LAUNCH LONG-RANGE BALLISTIC MISSILES ON COMMAND
NOMADIC PATROL
LOW LEVEL PENETRATION TO DESTROY HARD SITES
BASE WITH CONSTANT COMMUNICATIONS LINK
TYPICAL MISSION FOR ATOMIC BOMBER



Although many kinds of powerplants have been proposed for aircraft nuclear propulsion, two general configurations have received most attention. General Electric Co. pioneered the direct air cycle system, Pratt & Whitney started on indirect cycle.



sion in this "indirect" way. The direct cycle is the "older"' of the systems, but recent advances in the direct cycle indicate it may have more potential.

Two Different Designs/Approach

Each system has a design based on materials available, and another design based on "advanced" materials.

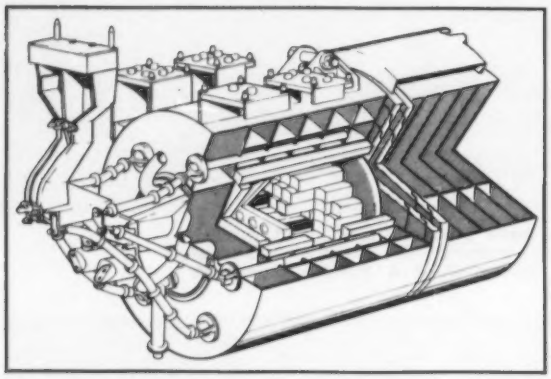
Air Force operational requirements for a nuclear powered aircraft is geared around some loose specifications of the CAMAL weapon system (Continuously Airborne Missile Launching and Low-Level Penetration). The aircraft would be at least trans-sonic. Navy requirement is for a sub-sonic ASW (Anti-Submarine Warfare), and early warning aircraft.

Convair won design competition for the CAMAL airframe early this year. A Phase 1 contract has not been awarded. Convair is allowed only to make modifications to this design, working within GE's powerplant achievements. This is odd, since experts seem to agree that GE's direct cycle system, using available materials, will not satisfy requirements of the CAMAL mission.

Decision Stalemate

Nuclear flight, however, is not beyond the state of the art. It can be accomplished. The major question is "when."

Major hassle in decision-making circles now seems to be: "do we build a nuclear aircraft



AIRCRAFT SHIELD TEST REACTOR

The ASTR is a 1000-kw reactor, cooled, moderated, and reflected by water. The core is made up of MTR-type enriched uranium fuel elements mounted between two plates and contained within a stainless steel pressure vessel. The control system was so designed that the reactor might be operated in any position. The reactor is part of air, and ground testing program on shielding.

A shield of lead and water surrounds the pressure vessel. The water portion of the shield may be varied by emptying or filling the various compartments in the shield tank. Some degree of flexibility in the lead shielding is afforded by removable lead rings. The outer surfaces of the ASTR shield are covered by boral to suppress leakage of thermal neutrons.

***From:** "Radiation Shielding Aspects of Nuclear Aircraft by N. M. Schaeffer and R. L. French, Convair-Fort Worth. SAE Annual Meeting, Jan., 1959.*

with present materials, knowing it will not meet any specific military mission requirements; or, do we build an aircraft with 'advanced' materials to fill a mission, without knowing what these materials are or how they will behave." Chief proponent of the idea which says "to fly now is to go down a dead end street of development," is Dr. Herbert York, director of Defense Research and Engineering at DOD. He stands almost alone, since Atomic Energy Commission, Navy, Air Force, General Electric Co., and Pratt & Whitney Aircraft Corp. are all eager to fly. But, Dr. York is probably the most powerful single force involved.

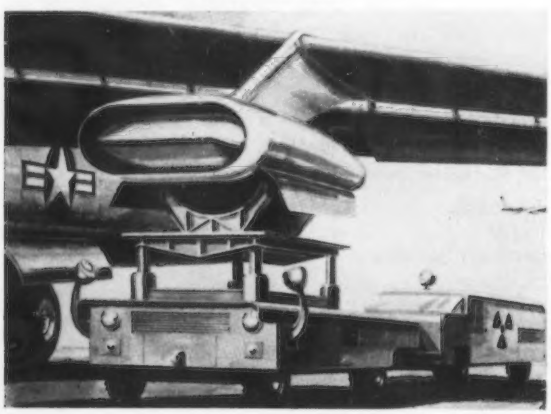
Lack of Objectives

The Joint Congressional Committee on Atomic Energy concluded from hearings completed this summer that "there has been a lack of concrete objectives and target dates for ground-test prototype propulsion system and for early flight" since the program started. It is difficult to define problems, and to delineate funds, for their solution, when the goal is nebulous. To help arrive at a logical goal some of the advantages offered by a nuclear aircraft should be examined.

Advantages of ANP

The nuclear aircraft replaces only one basic feature of conventional aircraft—chemical fuel. Removing the limitations of chemical fuel seems to offer several immediate advantages.

Atomic powerplants will have to be removed from the aircraft by remote mechanical means for maintenance. All ground support equipment will be shielded. Illustration is by General Electric Co.



ANP funding by agency, fiscal years 1946–60
[In millions]

Fiscal year	USAF		Navy, operations	AEC	
	Operations	Facilities		Operations	Facilities
1946	$1.3	.....	.....	.....	.....
1947	2.0	.....	.....	.....	.....
1948	6.2	.....	($1.0)	.....	.....
1949	6.9	.....	(.5)	.....	.....
1950	5.3	.....	.....	$1.4	$0.5
1951	2.8	.....	.....	5.5	.5
1952	10.0	$6.0	(.5)	10.7	.2
1953	22.6	6.3	.2	17.8	12.3
1954	6.2	.2	.1	15.2	3.1
1955	22.4	6.4	.5	23.9	.7
1956	46.4	57.4	3.7	46.7	3.0
1957	66.1	35.6	1.5	73.4	9.4
1958	60.5	2.4	2.9	66.6	9.0
Subtotal	258.7	114.3	8.9	261.2	38.2
1959 (est.)	63.4	5.8	3.5	72.8	[1]13.4
1960 (est.)	68.0	7.0	2.0	[2]73.4	.....
Total	390.1	127.1	14.4	407.4	51.6

[1] Based on current program planning, the total amount may not be placed under contract during fiscal year 1959.
[2] Excludes $0.3 of prefinancing.
Figures in parenthesis above are Navy funds transferred to Air Force which are included in the Air Force amounts. These amounts are not included in the Navy total.

They are:

- "Unlimited" range.
- Payload growth independent of range.
- Continuous low-altitude patrol.

Commercial use of these advantages is questionable, since the economics of ANP cannot be fully studied at this early date. The advantages are, therefore, usually viewed only from a military standpoint.

UNLIMITED RANGE can be translated into distance, endurance or a combination of both. This permits basing aircraft in U. S., or where lines of supply are quite short, without the burden of tanker aircraft. It permits an omnidirectional approach to a target. It therefore creates a staggering defense burden on an enemy.

PAYLOAD GROWTH allows ANP aircraft to increase payload directly with thrust to weight improvements. Conventional aircraft weights increase nearly exponentially for increased range with constant payload. A given design must sacrifice range for increased payload.

CONTINUOUS LOW ALTITUDE PATROL and penetration are important to having a mobile striking force that is not easily detected by enemy radars. The extreme fuel consumption of chemically fueled aircraft severely limits patrol and penetration "on-the-deck."

Mobility of Defenses

In comparing the ANP aircraft striking force to the pure missile force, two important advantages are dominant for the aircraft. The aircraft is capable of quick response to target assignment, and the aircraft is recallable should last minute evaluation rule out attack.

We are planning mobility into our own missile systems as a defense. There is no reason to believe an enemy would not do likewise. Present ballistic missiles are not effective against any sort of moving target.

At present these are the considerations which justify ANP, so they are essentially the ones that should be considered in making the goal less nebulous.

The Air Force CAMAL weapon system is, in a way, an airborne extension of the Polaris concept—mobility. The CAMAL weapon is envisioned as a Mach 0.9 to 1.1 aircraft, capable of carrying "several nuclear armed ballistic missiles." It would remain airborne about one week at a time, and would be capable of reaching any point on earth.

Some Problems—Some Requirements

These are some of the problems, and problem areas which remain.

- Development of actual power package, i.e., reactor-turbine system.
- Refinement of shielding system.
- Researching effects on materials at high temperatures.
- Development of ground support equipment.
- Environmental testing of subsystems.

Much of this has been accomplished on the ground. Some of it will never be accomplished on the ground. There is an interrelationship between ground and air testing. Air and ground tests must at some point be carried out simultaneously. But when?

Some requirements and conditions which make an airborne nuclear reactor different from ground-bound reactors and chemical powerplants are these:

(1) Coolant temperatures in operating power reactors constructed to date are in the area of 500 to 850°F, while aircraft reactors must employ temperatures at two or three times this. Turbine inlet temperatures for conventional jet engines are in the area of 1,600 to 1,800°F.

That is a comparison of 500 to 850° versus 1,600 to 1,800° and is just a fair measure of how difficult the problem is.

(2) Average core power densities for aircraft reactors must be considerably higher than anything produced in other power reactor programs.

(3) Aircraft applications impose critical restrictions on reactor and shield assembly size because of the severe aerodynamic penalties imposed by large frontal area.

(4) The thrust-to-weight ratio of a nuclear powerplant suffers by comparison with present day chemical jet engines. To a degree this is offset by the weight of fuel carried by a conventional airplane. But this weight is distributed, whereas the concentrated weight of the nuclear engine and its shielding introduces increased structural considerations. A more favorable comparison can only be attained by an increase in the temperature capabilities of the reactor propulsion system.

The Reactor Mechanism

Regardless of the type engine which receives the heat to propel the aircraft, mechanisms and problems at heat source do not basically change. They are high temperature problems and radiation problems.

The reactor can be thought of as a cylindrical body, with uranium-235 or plutonium-239 distributed throughout the core. There must be provision to allow passage of a coolant which removes the heat from the reactor. There must also be provisions for a moderator material.

continued on next page

atom aircraft . . . continued

Over-simplified, the reactor operates in this way. A "large" neutron from the starting source is captured by the nucleus of the uranium-235 atom. The U-235 nucleus begins to disintegrate and 2 or 3 neutrons and 2 atomic nuclei are given off. The latter are fission fragments. Gamma rays, beta rays, and heat are given off in the fission process.

The several neutrons are ejected into the body of the reactor and either:

- Escape entirely to be captured by an outside shield.
- Are captured by some non-fissionable material within the reactor.
- Are captured by some other U-235 nucleus in the reactor, to in turn give off additional neutrons. Hence, chain reaction is started.

Basic problem is to reduce to acceptable limit "leakage" of neutrons by the first two methods. Part of the tremendous "material" problem in developing a powerplant is finding those metals which least absorb neutrons within the reactor.

Moderators like beryllium oxide are effective in reflecting stray neutrons back at the U-235 for absorbtion. These moderator materials therefore line the core. Reflected neutrons naturally lose some of their speed and are more easily captured to aid in the fission process. Keeping neutron absorbing materials out of the reactor is essential to getting it "go critical," i.e., sustain a chain reaction. If 40 percent of the neutrons can be made to stay in the reaction, it will continue to depletion of source.

Control mechanism for the chain reaction can also be over-simplified by saying that a neutron absorbing "rod" is inserted into the reactor to varying extents. From a given starting point, where the reactor is neither gaining nor losing power, exposing more of the absorbing rod will cause a drop in power, exposing less will cause a rise in power.

Shielding

An unshielded aircraft nuclear reactor would have enough leakage to make it unsafe to approach closer than about 1 mile. Since fission products continue to emit gamma rays even after the chain reaction is stopped, the shielding problem remains in ground servicing.

Two kinds of leakage must be shielded against? (1) neutrons, and (2) gamma rays. Neutrons are slowed down most by light atoms such as hydrogen. Gamma rays are slowed down most by heavy atoms like lead. Any shield-reactor combination would incorporate light and heavy material, it would weigh over 50 tons but less than 100 tons.

Split or Unit Shields

One possibility for reducing shield weight is to put some of the shield around the crew, and some around the reactor. The crew is given the same amount of protection in this way with less shield weight. The aircraft itself and the air space between the crew and reactor absorb some of the radiation.

Navy (Admiral Hayward) states that one objection to the GE direct-air-cycle engine is the shielding concept. "We do not believe in direct air cycle . . . it has fundamental drawbacks. It has the divided shield instead of the unit shield. It exposes all of the equipment to radiation. We just cannot live with it." Navy wants a 60 to 100 megawatt indirect cycle for preliminary use with turboprop engines. The mission would be ASW and early warning. Air Force is now turning to indirect cycle but put early work in direct cycle; does not feel the problems cannot be "lived with."

Unit Shield

The shielding problem is somewhat relieved by use of the indirect cycle, but with the penalty of increased weight. Here again complications are introduced. The heat loops for the liquid must also be shielded since the coolant may become radioactive, either by direct fission-product leakage, or by neutron-induced radiation.

With either system it is obvious that ground maintenance, including engine changes will have to be done by remote mechanical means. This involves shielded hangar, and shielded towing and lifting devices, thus taxing of every state of aircraft operation.

Seaplane Approach

Runways of sufficient length to get such an aircraft airborne and back could become a problem. This is especially true considering ground handling, and forced landing. Thus, the seaplane has been suggested as a good configuration. This leads to Air Force-Navy politics. Navy has stated, however, that if it is necessary to go to seaplane configurations for "early flight," that plane can have "U. S. Air Force" painted on its side.

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Chestnut & 56th Sts., Philadelphia 39, Pa.

METALWORKING Briefs

Inert-Gas Welding Fixes Damaged Cooling Turbines; Saves Navy $2150 Apiece

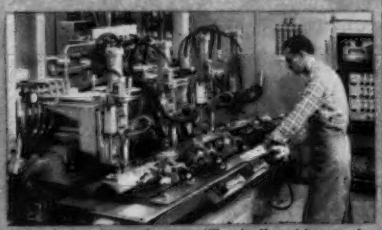
Basic economics: If a damaged cooling turbine costs $2300 to replace, you try to fix it first. When Norfolk Naval Station faced this problem, they found that only inert-gas tungsten-arc welding could make the delicate welds needed to secure the .004-in. special stainless alloy fins.

After damaged fins are cut from the hub, the section is machined to a U-shape and ground to a satin finish. New fins are welded in place with a HELIARC HW-10 torch. The HELIARC welds easily withstand the turbine vibration of 14,000 revolutions per minute and temperatures over 1750 deg. F. *Total cost of repair: $150.*

New Tape-Controlled HELIARC Machine Mass-Produces "Problem" Missile Parts

A tape-controlled, multi-torch machine, invented and developed by LINDE, makes more than 2500 HELIARC spot welds per hour on problem parts for "Terrier" surface-to-air missiles built by Convair. The machine covers a 20x80-in. area. Accuracy is better than .001 in. and welds meet shear-strength requirements of 2000 lbs. each.

Since many "Terrier" parts, such as control and dorsal fins, can be welded from only one side, resistance spot welding is impossible. HELIARC spot welds are ideal because they require access to only one side. The fins are made from 1020 carbon steel and 17-7 ph stainless, varying from .0016- to .0090-in. thick.



2500 spot welds an hour on "Terrier" problem parts.

A punched-tape controls the weld locations, torch combinations, time and current at each step. These LINDE machines are adaptable to semi- or fully-automatic production. They can be equipped with enough HELIARC torches to produce a theoretically unlimited number of spot welds simultaneously.

HELIARC spot welding utilizes a new LINDE-invented method of positive and instantaneous arc ignition—Pilot-Arc starting—which eliminates all high-frequency interference and avoids the contamination of retract starting.

Although particularly suited to the aircraft and automotive industries, HELIARC spot welding is a precision process, adaptable to any industry which demands complete mechanization, high speed, and top quality on a mass-production scale.

MECHANIZED WELDING QUADRUPLES ALUMINUM AIRCRAFT PARTS OUTPUT

A quick switch, from manual to mechanized welding, has more than quadrupled production of oil-temperature regulators and fuel-to-oil heat exhangers at Airesearch Manufacturing, Los Angeles.

SWM-2 SIGMA welding machines join the 6061 aluminum parts at speeds up to 85 inches per minute. Replacing manual covered-electrode welding, LINDE's inert-gas process reduced production time on the heat exchangers from one hour to 13 minutes, and on the regulators from 40 minutes to ten minutes. As a result, daily production of these two units has increased from 8 to 35 and 12 to 48, respectively.

Short Work With "Short-Arc"

To increase production of tank-ejector units while reducing costs, Fletcher Aviation, Rosemead, Calif., replaced covered-electrode welding with LINDE's new "Short-Arc" welding process. It uses a 16-oz. torch with a low-voltage, short-arc for easy control of steels .030 to ⅛-in. thick.

The high welding speed, semi-automatic operation, and slag elimination (photo) increased Fletcher's production from 50 to 300 units a day. Unit cost shrank from $1.14 with covered-electrode welding (labor and overhead, $1.12; consumables, 2¢) to only 29¢ (labor, 19¢; consumables, 10¢)—a saving of 75 per cent.

America's Missiles and Satellites Soar On HELIARC and SIGMA Welded Joints

Inert-gas shielded-arc welding plays an important role in fabricating American satellites and missiles. The Army's "Explorer," made from .025-in. stainless at Cal Tech's Jet Propulsion Lab, Pasadena, and the Navy's "Vanguard," made from .090-in. magnesium alloy at Brooks & Perkins, Detroit, are both welded with LINDE's HELIARC HW-9, HW-17 and HW-18 torches.

Rocketdyne Division of North American Aviation, Canoga Park, Calif., uses HELIARC welding on the Redstone engine's heat exhanger, thrust chamber, and peroxide tank. The process makes top-quality welds on all the parts, despite the varying thicknesses of aluminum and 17-7 ph stainless.

Reynolds Metals' missile plant in Sheffield, Ala., uses mechanized SWM-3 SIGMA welding to make more than 1000 ft. of welds on the 5086 aluminum outer jacket and center section of the "Redstone" and "Jupiter-C" missiles. The longitudinal and circumferential welds reach speeds up to 100 inches per minute.

During all fabrication, the HELIARC and SIGMA welds are protected from atmospheric contamination by 99.995% pure LINDE argon.

Precision welding pays off—neither the satellites nor the missiles have ever failed due to faulty welds.

FOR DETAILS . . . on any of LINDE's modern welding methods and for regular copies of LINDE's 24-page, bi-monthly METALWORKING BULLETIN, write Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited. "Linde," "Heliarc," "Sigma," "Unionarc," "Unionmelt," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

Linde UNION CARBIDE

Circle 7 on Inquiry Card

design considerations for– direct-air-cycle

by W. F. Savage, manager
applications technical analysis,
General Electric Aircraft Nuclear Propulsion Dept.

Using controlled nuclear fission for aircraft propulsion seems extremely desirable. This is well understood if we consider that one pound of uranium-235 liberates about the same amount of energy as approximately 1,700,000 lb of gasoline. Nuclear propulsion could lead to an aircraft with almost unlimited range.

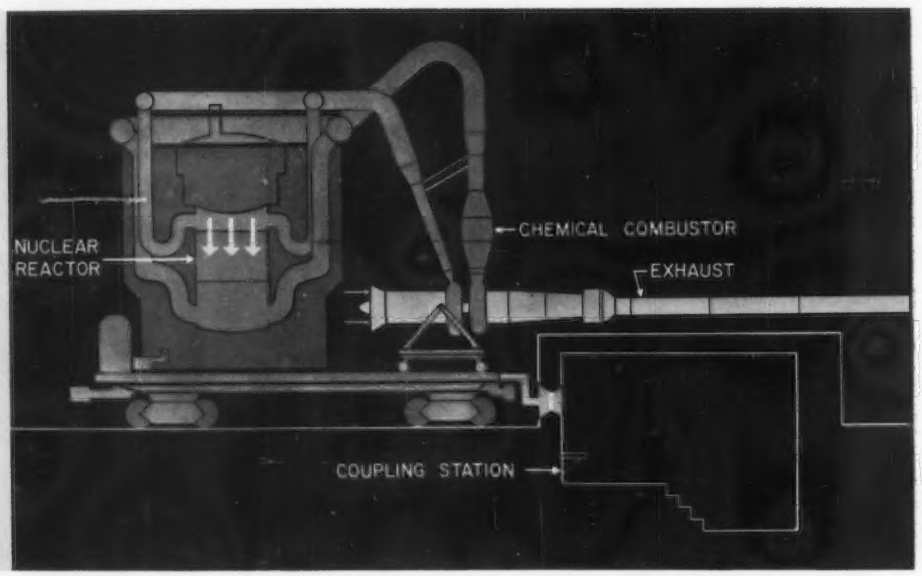
Direct Air Cycle and HTRE

In 1951, Air Force asked the General Electric Co. (GE) to develop a nuclear power plant suitable for aircraft propulsion. It was decided by GE that the direct-air-cycle, in which the air is heated by passing directly over the fuel elements, offered the best promise for future growth. The direct-air-cycle also offered a basically simple nuclear powerplant system with flexibility in application, and ease of handling.

The feasibility of the direct-air-cycle was proven in 1956 when Heat Transfer Reactor Experiment #1 (HTRE-1) was run. This test proved that a turbojet engine could be run for long periods on the heat generated by nuclear fission. The basic HTRE-1 test apparatus is illustrated. It consists of a water moderated reactor structure wherein a cylindrical water vessel was penetrated by air tubes, a large test shield assembly, two modified J-47 turbojet engines, and associated ducting and accessories. As shown in the accompanying schematic, the air entered the compressor, passed out the compressor scroll, and then was ducted into the reactor which was located in a large water, lead, and steel shield. The air passed through the

Experimental reactor was first run in 1956. Tests have continued. Reactor is water-moderated, and proved feasibility of direct-cycle system.

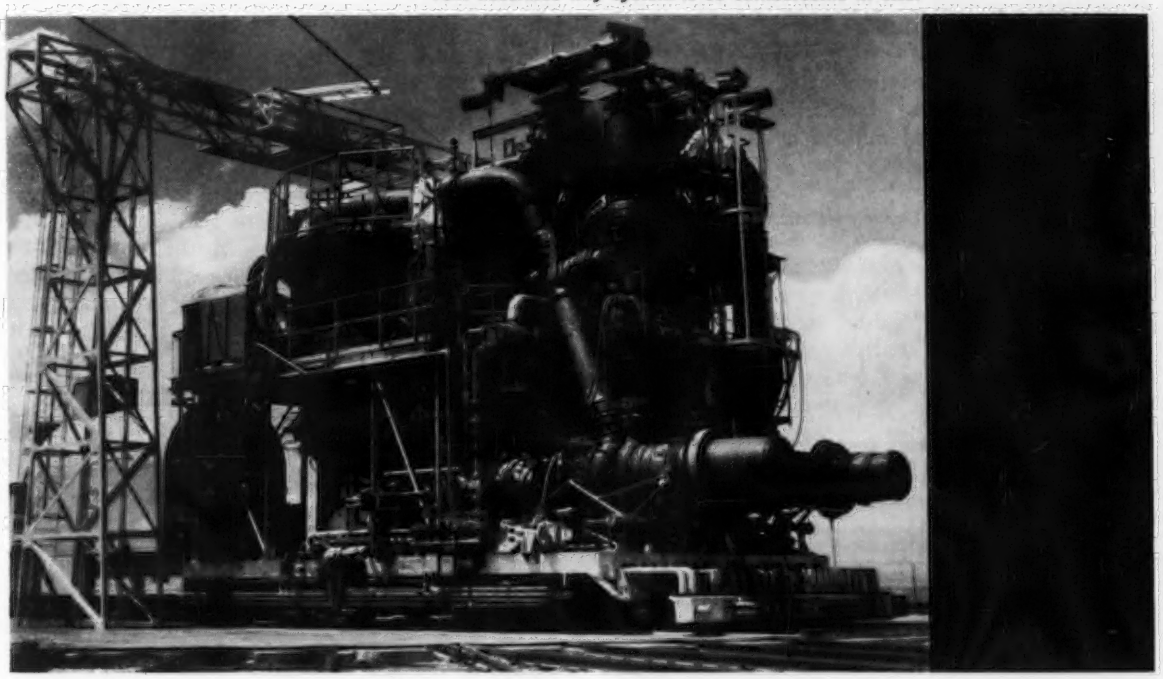
SCHEMATIC OF HEAT TRANSFER REACTOR



powerplant

shield is primary problem, should stop radiation and have structural strength; split-shield seen as weight saver

Photograph of flat-car mounted apparatus shows two J-47s which were run for 100 hr without failure. Text describes why system is so cumbersome in size.



reactor and then out through a ducting system through a chemical combuster and through the turbine section of the turbojet. It was then exhausted through a high stack. The chemical combuster was supplied so that the engine could be operated by either chemical or nuclear means.

Why HTRE Apparatus Is Large

The very large structure around the test system was necessary for the following reasons:

- The shield used was that necessary for safe ground test operation. It would be drastically reduced in size for an airborne power plant.
- Since the reactor generates heat even after control rods are inserted, there must be some means of maintaining airflow over the reactor even though the turbojet is not operating. This requires aftercooling blowers which are also located on the test rig. Instrumentation and auxiliary power equipment for an initial test of this type are extremely large and therefore add to the complexity of the test setup. In an ideal aircraft nuclear power plant the chemical combustion section found in a conventional turbojet engine would be replaced by the reactor and a shield would be placed around this reactor.

What Was Gained

HTRE No. 1 proved that it was feasible to run a turbojet on nuclear energy. The turbojet engine was operated completely on nuclear power

for over 100 hr without failure of any type. Additional heat transfer reactor experiments have been run and these are leading to a nuclear power plant having a high thrust-to-weight ratio which will be utilized to fly a nuclear aircraft.

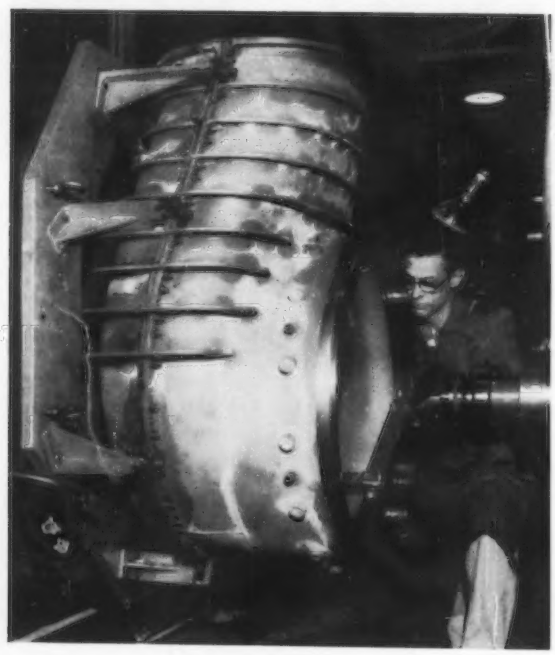
Divided Shield—A Weight Saving

Since it is a necessity that weight be kept to a minimum in any aircraft, extensive tests have been, and will continue to be, conducted on shield materials and advanced shield concepts. In the early tests it was discovered that there was an optimum balance of shielding between the aircraft crew and the aircraft power plant, e.g., a certain portion of the total shield should surround the crew compartment and the remainder should be placed on the nuclear power plant. Such a division would yield minimum weight. If this were the only problem as concerns the divided shield concept, the weight of such a system would be fairly low. However, it may not always be possible to carry out the optimum division. This is so because other aircraft components and materials may be subject to radiation damage and activation. It is known, for example, that some electronic components, primarily transistors, are prone to radiation damage. Certain materials can become highly radioactive and will remain so for extended periods if left in the vicinity of a partially shielded reactor. Table 1 presents some of the more serious gamma emitters as far as induced activity is concerned.

Table I. Gamma emitters—Induced activity

Basic Material and Product	Half-Life
Ni^{58} (n,p) Co^{58}	72 days
Fe^{58} (n,γ) Fe^{59}	45 days
Cr^{50} (n,γ) Cr^{51}	27 days
Co^{59} (n,γ) Co^{60}	5.3 years
Ta^{181} (n,γ) Ta^{182}	112 days

Scrolls which pick up compressor air for reactor, and then deliver reactor-heated air to turbine are apparent in the schematic. Manufactured by Ryan Aeronautical Co. from special steel, they are nearly 5 ft high.



Radiation Leakage

Other shielding problems which evolve from direct-air-cycle nuclear power plants are those of allowing the air to enter and leave the reactor and yet prevent the radiation from streaming through the inlet and outlet ducts. This can be partially prevented by using staggered struts, and offset perforated plates, or a number of bends. Pressure loss between the compressor and the turbine will, however, increase as such devices are added.

Since the operation of the power plant depends on both the pressure and temperature level of the hot air in front of the turbine, it is necessary that pressure losses be also kept to a minimum. It is, therefore, necessary to determine the optimum combination of duct configuration from both the shielding and pressure loss point of view.

Neutron Shielding Materials

Selection of shield materials must be predicated upon not only shielding effectiveness, but on maximum shielding effectiveness per unit of weight. The shield must be designed to attenuate both neutrons and gamma rays. Hydrogen would be the best for neutron attenuation, since it has the lowest atomic mass. Of course it is impossible to have free hydrogen in the shield, therefore, compounds containing this element could be used. One of the most commonly used is water. Due to heat liberation in the shield, liquids offer a disadvantage; they boil at fairly low temperatures unless used in pressurized systems. In any case fairly large heat-exchangers are required. Other likely elements for neutron attenuation are, in order of their atomic weight, lithium, beryllium, boron, and carbon. Some compounds of these elements may offer possibilities.

Gamma Shielding Materials

The gamma shield must be a very heavy or high mass material. Some of the materials

which appear useful are tungsten, lead, or iron. Lead has the disadvantage of melting at a very low temperature. Tungsten is fairly difficult to fabricate. Steel can be used with boron. Boron acts as a secondary gamma suppressor and iron as a primary gamma absorber.

Structural Considerations

Weight, and radiation absorbing properties of shielding materials, are not the only criteria which influence selection. Materials are also selected on the basis of having sufficient structural strength. Here again, lead would be ruled out.

This can be better understood if the mounting of the engine is considered. Since the reactor shield assembly would most likely carry the main support mounts for the power plant, there must be some way of carrying the loads through the shield into the mounting trunnions. Either a separate support structure can be used, or as mentioned above, the shield itself can transmit the loads to the trunnion. It is up to the engineer to make a judicial choice of shielding material, weighing strength, radiation attenuation, and lightness considerations.

High Density Reactor

In reactor design, it is necessary to have a minimum-weight reactor delivering the maximum amount of power. Such a reactor is called a high density reactor. That is, a large amount of heat is generated per pound of material. In a typical design, air would flow along the "fuel elements" in the reactor and pick up heat from the hot element surfaces. The fuel medium could consist of a tube or plate with an oxidation resistant cladding. Heat would be generated by nuclear fission in the fuel medium. Surrounding the clad fuel surface would be the moderator, composed of light elements. It would be desirable for the moderator to contain as much hydrogen as possible, and for this reason, water is used as a moderating material in many nuclear reactors.

Solid moderator materials containing hydrogen would be very desirable for high temperature operation, since no secondary heat exchanger would be required for moderator cooling. As in the case of the neutron shielding, the moderator may also employ materials such as beryllium or carbon either in virgin or compound form. Beryllium does not have the slowing down power of hydrogen and therefore is not as good a moderator. The moderator and the fuel elements can be joined together by means of a support structure located at both the forward and rear ends of the reactor.

The rear structure presents a problem since it will "see" the hottest air in the system. The reactor may be held together at the hot end by means of an external strap or clamp or by simply cantilevering the entire reactor structure off the cool front structure. Once again the problem of reactor design is one of obtaining materials which can operate at very high temperatures in an oxidizing atmosphere and yet have structural integrity at these temperatures.

Nuclear "Poisons"

Another problem which is not apparent from normal heat exchanger design now becomes very important in reactor materials selection. This is the problem of nuclear poisons resulting from improper selection of reactor materials. Such problems can result from the inclusion of very small amounts of impurity in the base matetial. For example, traces of boron, hafnium, cadmium, or gadolinium will result in very poor nuclear performance. These materials tend to absorb large amounts of neutrons.

At the same time, reactor structural materials must not become highly activated in short periods of time or result in isotopes having long half-lives. Even if the fuel elements are removed, it will be extremely difficult to handle the reactor if long half-lived, highly radioactive isotopes are present. Among suitable structural materials for core use are Inconel X or Hastalloy X. Molybdenum does not appear to be desirable due to its absorbing qualities and the fact that protective coatings must be applied in an oxidizing atmosphere.

Cooling After Shutdown

Although mentioned previously, the problem of afterheat removal is of primary importance in the design and operation of direct cycle nuclear power plants. After the reactor is shutdown, a significant quantity of heat is generated by gamma radiation in the reactor. If cooling air is not supplied, fuel element meltdown might occur. The time at which meltdown occurs is dependent upon the time and power level of previous operation. It is therefore required to know the previous reactor operating history if aftercooling is going to be delayed for removal of the power plant from the aircraft or for disassembly of certain portions of the power plant.

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Smaller, lighter, wider range

PNEUMATIC MISSILE REGULATORS

Shown are three pneumatic regulators from among the hundreds of sophisticated missile components developed and manufactured by Wallace O. Leonard, Inc. during the past ten years. Accommodating air, nitrogen or helium, these regulators are smaller and lighter than units of comparable capabilities, have a wide range of inlets and flows, have no buzz, and are practically insensitive to vibration and shock. Note specific performance data and parameters. These Leonard regulators are now in use on many major missile systems and in ground support.

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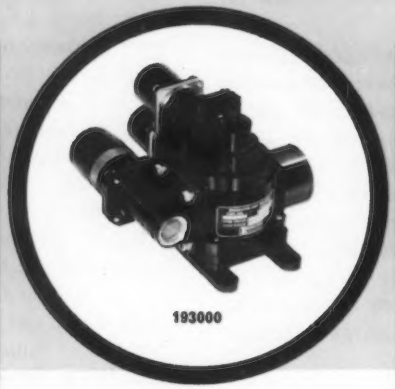

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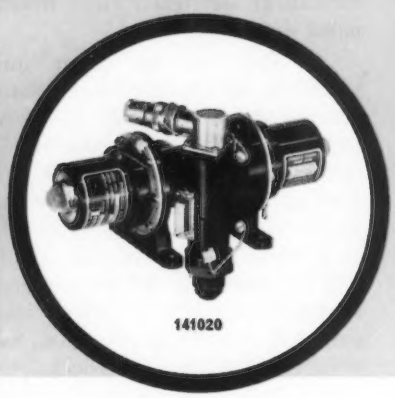

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APPLICATION	MISSILE FUEL AND OXIDIZER TANK PRESSURIZATION. Maintains Constant Pressure During Firing Cycle.	PNEUMATIC STEERING NOZZLE SUPPLY Provides Accurately Controlled Gas Pressure to Nozzle for Missile Positioning and Stability Operations.	INSTRUMENT AIR BEARING SUPPLY Provides Precisely Regulated Gas Pressure for Guidance Components. Maintains Regulation Level and Control Over Wide Range of Inlet Conditions and Environments.
General Information	Available with Solenoid Shut-Off and Position Indicators	Integral Relief Valve Solenoid Actuation Optional	Available with Solenoid Shut-Off, Relief Features, etc.
System Medium	Air, Nitrogen or Helium	Air, Nitrogen or Helium	Air, Nitrogen or Helium
Pressure Data			
Regulating Range (Typical)	13-25 PSIG ±.5 PSIG	300-400 ±5 PSIG	30 to 55 ±.2 PSIG
Inlet Pressure	3000 to 600 PSIG	3000 to 600 PSIG	3000 to 200 PSIG
Proof	4500 PSIG	4500 PSIG	4500 PSIG
Burst	7500 PSIG	7500 PSIG	7500 PSIG
Flow	5-40 lbs./min.	6-24 lbs./min.	8 to 20 SCFM
Leakage			
Relief Port		10 cu. in./min.	2 cu. in./min.
Internal	10 cu. in./min. (when shut off)	10 cu. in./min.	1 cu. in./min.
External	Zero	Zero	1 cc/hr.
Temperature Range	—65° to +165° F	—65° to +165° F	—65° to +165° F
Vibration	MIL-E-5272, Proc. 1	MIL-E-5272, Proc. 1	MIL-E-5272, Proc. 1
Acceleration	20 G's (1 plane)	20 G's (1 plane)	20 G's (1 plane)
Weight	3.5 lbs.	3.7 lbs.	1.45 lbs.

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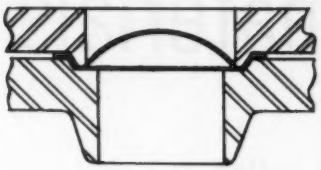
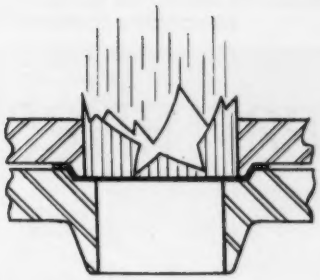


As long as pressure remains below the pre-determined point at which the dome-shaped disc will rupture, a leak tight seal is maintained.



When pressure attains the rated rupture point of the disc, instant release is provided through full orifice diameter by the outward bursting of the rupture disc.

An Advanced Approach To Pressure Systems Design

How To Reduce Weight Factor In Pressure Release Mechanisms

Although BS&B Safety Heads, in one form or another, have been providing over-pressure protection for closed pressure systems in numerous industries for more than 25 years, it is only recently that they have come into their own as pressure release devices for various types of airborne equipment.

Recent metallurgical and engineering developments, as well as improved manufacturing procedures, have made the BS&B Safety Head today's lightest weight, most accurately calibrated pressure release device ever developed. A typical Safety Head consists of a metal rupture membrane secured in mounting flanges. There are no moving parts.

Weakness A Virtue

The rupture membrane, or disc, is a purposely designed "weak spot" in the pressure system. Over-pressure bursts it at a pre-determined set pressure rating.

Full relief area is achieved instantly. When the disc ruptures a full throated opening is provided. This outstanding feature is most advantageous in pressured systems where ignition or exothermic reaction during a process causes abnormal pressure rise in seconds or milliseconds.

. . . This briefly, is the function of a BS&B Safety Head as related to over-pressure protection.

Imagination The Only Limiting Factor

The application and design of Safety Heads is continually being expanded. BS&B Safety Heads are serving the aircraft and missiles industries in ground, air and marine applications.

As an example . . . visualize the rupture disc as a seal to retain pressure in a chamber, and actuated (burst) by pressure developed within seconds or milliseconds. The pressurized fluid is thus discharged into another chamber. Here ignition may take place with contact of another fuel component. Chemical reaction may instead serve to further energize the system.

As a different application of the same basic device, the rupture disc of a Safety Head could serve as a signaling device . . . or to retain pressure to a pre-determined point whereupon it would then be actuated by an explosive squib or primacord.

Peculiarly Suited To Airborne Mechanisms

Weight is of prime concern in airborne equipment. The smallest Safety Head now in production weighs only a fraction of an ounce. It is about the size of a large pea. In spite of its minuscule specifications it still retains all of the design features and precise operating characteristics so essential to satisfactory performance.

Big Or Little, High Pressure Or Low

BS&B Safety Head sizes range from ⅛" to 44" in exposed diameter of the rupture disc. Pressure rating for the disc can be anywhere from 5 psi. to 100,000 psi. Mounting flanges and rupture disc metals can be varied over a wide selection to accommodate exposure to acids or other corrosive conditions as well as to elevated and sub-zero temperatures.

Hundreds Of Design Variations Possible

If you need pressure release devices of small size and light weight for missiles and JATOS, or large sizes for ground fueling systems and engine test facilities, you should examine the advantages of using BS&B Safety Heads. Chances are there is a Safety Head of the necessary characteristics available from present designs. If not, it can be custom built to your specifications.

Here then are just a few of the reasons why BS&B Safety Heads can serve you better in many different applications...

- A pressure relief device with controlled release accuracy.
- Leak tight.
- Light weight.
- No movable parts.

For answers to your specific questions contact the Safety Head Division at the General Offices in Kansas City, or the BS&B Field Sales Office or Sales Agent located nearest you.

BLACK, SIVALLS & BRYSON, INC., Safety Head Division, Dept. 2-GC12
7500 E. 12th Street, Kansas City 26, Missouri

Circle 9 on Inquiry Card

nuclear effects on materials

**engineering properties suffer,
organics seem most affected;
designers need new data for nuclear environments**

Nuclear radiation brings about appreciable changes in the engineering properties of materials. Malfunction or failure of a complete system can occur as a result of prolonged exposure to the nuclear environment. Extensive efforts have, therefore, been focused on the problem of radiation effects in materials. Objectives are to gather design information on the behavior of existing materials in a radiation field, to improve their radiation resistance, and to search for replacement materials of superior radiation resistance.

Concentrate on Organics

The present developmental and technical effort is almost exclusively concentrated on the much more radiation-sensitive organic materials. However, one class of inorganic materials, semiconductors, is also being actively studied. Their electrical properties exhibit a very sensitive response to radiation exposure.

Of the radiation generated in a nuclear reactor, gamma rays and fast neutrons are of most concern.

GAMMA RAYS interact directly with the orbital electrons of the organic compound. This action may result in the breaking of chemical bonds, the formation of intermediate reactive species, and the ultimate rearrangement of these species into new chemicals. In other words, irreversible chemical reactions are initiated by the radiation in the material.

FAST NEUTRONS interact with the atomic nuclei of the organic compound by elastic collision. In such cases, an appreciable part of the neutron's energy is transferred to the target atom. The atom is ejected from its molecular complex, and dissipates its energy by interacting with the orbital electrons of the atoms which it encounters. This interaction ultimately produces the same types of chemical effects as gamma rays.

The result of organic materials absorbing high-energy radiation may be likened to the entry of an angered bull into a china shop. That is, the energy of these radiations is several orders of magnitude larger than the bond energies between the atoms of the organic molecules. There is an indiscriminate transfer of energy to the various chemical bonds in the organic molecules. Ensuing chemical events depend almost solely on the chemical nature of the various primary reaction products, and that of the surrounding unaffected molecules of the compound.

LOW-MOLECULAR-WEIGHT COMPOUNDS such as lubricating oils, the radiation-induced reactive species may set up a chemical chain reaction in which the originally small molecular units are linked together in repetitive succession to form large threadlike molecules. This process is called polymerization. It manifests itself in a progressive increase in the viscosity of the compound and, finally, in complete solidification.

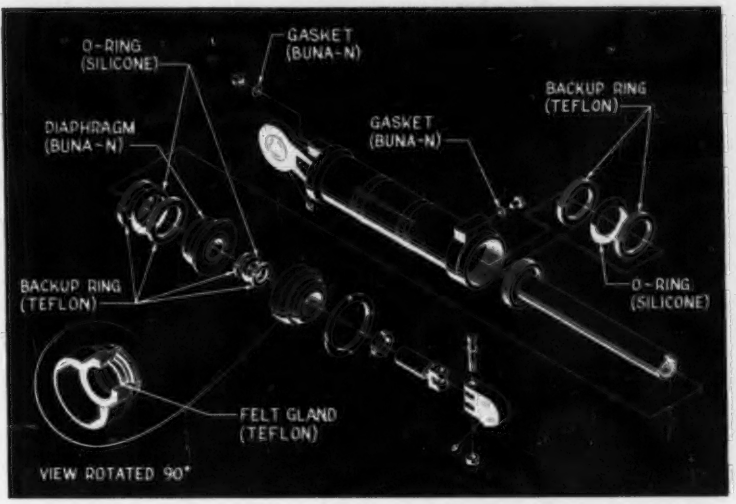
HIGH-POLYMER MATERIALS, such as rubbers and plastics, undergo similar changes. However, the physical properties of high-polymers exhibit a greater sensitivity to small changes in chemical bonding.

DETERMINATION OF FUNCTIONAL LIFE OF LANDING GEAR ACTUATOR COMPONENTS

Component	$E_T = E_n$ / $E_n + E_\gamma + E_n$ ergs/gm-sec	Functional Threshold (T) ergs/gm	Predicted Life = T / E_t (3.6×10^3) (hrs)
Gasket (Buna-N)	2.5 (3)	8.5 (9) (1)	945
Backup Ring (Teflon)	1 (3)	10^7 (2)	2.8
O-Ring (Silicone)	2.1 (3)	1.8 (9) (3)	238
Felt Gland (Teflon)	1 (3)	3.7 (6)	1.0**
Diaphragm (Buna-N)	7.5 (3)	8.5 (9) (1)	945

(1)—As determined by AMS-3205.
(2)—As determined by MIL-R-8791.
(3)—As determined by AMS-7274.
**—Weakest Component

MAIN LANDING GEAR ACTUATING CYLINDER COMPONENT BREAKDOWN



"Weakest link concept" shows that existing landing gear actuator would have only 1.0 hr useful life in radiation field. Teflon felt gland would fail.

Two types of radiation-induced reactions, are particularly important in high polymers: crosslinking and chain degradation.

IN CROSS LINKING, side groups along the main molecular chain are severed from the chain, leaving chemically reactive sites. These reactive sites attach to similar points along the neighboring chain so that primary-valence crosslinks are formed between formerly disunited molecules. If the severed side groups are sufficiently small, they may accumulate as gas bubbles within the material or diffuse out of it altogether.

IN CHAIN DEGRADATION, the main molecular chain is irreversibly fractured so that the molecular weight of the compound is progressively reduced.

The Designer's Problem

The design engineer is, of course, not directly interested in such radiation-induced changes on the molecular level. What he wants to know is how these chemical events affect the engineering properties of the materials he plans to use.

Unfortunately it is not possible to reliably predict, on a merely theoretical basis, the behavior of engineering materials. Extensive testing is the only answer.

One approach has been to screen and classify candidate materials by "functional threshold." This is the upper limit of radiation dose which can be tolerated without impairing the functional use of the material in an overall system. Acceptable behavior is based on established engineering standards, such as military specifications, ASTM and ASA standards.

"Weakest Link," in Component Tests

In the preliminary screening, it became soon apparent that the isolated testing of materials did not yield a realistic picture of their behavior as components in a sub-system. Therefore, entire sub-assemblies were subjected to a nuclear environment to simulate as closely as possible expected service conditions.

The "weakest link" concept has been particularly useful in the testing of such sub-assemblies. Critically radiation-sensitive components ("weakest links") which lead to the malfunction of the sub-assembly are first recognized. These components are then eliminated from the system, replaced by a more radiation-resistant material. If that is not possible, the sub-assembly is redesigned or re-located.

Elastomers

Elastomeric materials are particularly suitable for sealing metal surfaces to prevent passage of gases or liquids. They are employed in the form of gaskets and sealants. Their use is due primarily to two properties: (1) good "spring back" and (2) poor permeability to gases and liquids. These properties should be retained after irradiation.

A promising elastomeric compound for use in a radiation environment is Synpol 1500, a styrene-butadiene copolymer. R. E. Morris recently

reported to Naval Air Material Command, "properly compounded, Synpol 1500 is the best rubber for use in gaskets and seals exposed to a high-intensity radiation field." However, this rubber is not resistant to petroleum oils and gasoline. Hence, whenever the gaskets are required to perform adequately in the presence of liquid hydrocarbons another material need be selected.

One such suitable elastomeric compound is Hycar 1072, an acrylonitrile-butadiene copolymer, modified to contain carboxyl groups. This material is usable after a dosage of 10^8 roentgens.

If gaskets and seals are to be used in contact with aromatic liquids another related compound Hycar 1071, offers a more specific resistance towards the combined degradative action of this type of liquid and radiation. Hycar 1071 is similar in chemical composition to Hycar 1072 except that it contains more acrylonitrile. It is, however, slightly inferior to Hycar 1072 in pure radiation resistance.

The Fluoroelastomers

Fluoro-rubbers elastomers exhibit the highest known heat stability combined with an excellent retention of their properties at elevated temperatures. Unfortunately, they are the poorest performers in a radiation environment. They lose their desirable physical properties at a comparatively low radiation dosage and also liberate corrosive products that attack the metal surfaces touching them. They should be avoided where high radiation fluxes are present.

When the application calls for combined temperature and radiation stability, silicone rubbers have to be used. This class of components, though having inferior elastic properties, exhibits good high temperature characteristics and a radiation resistance much superior to fluorinated polymers.

Back-Up Rings

Back-up rings also called nonextrusion rings, are used in aircraft fluid-systems to prevent extrusion of O-rings at or above 1500 psi. Properties which make a material good for back-up rings are: good resiliency, tear resistance, low coefficient of friction, temperature stability, and compatability with the system fluid. Leather, metal, Kel-F and Teflon are widely used.

After exposure to reactor radiation, a battery of materials was tested for elongation, tensile strength, impact strength, and water absorption.

Convair reports these findings: "Teflon, although superior in non-nuclear applications, is one of the poorest materials for radiation resistance. Kel-F, followed by Viton A, offers the best organic replacement for Teflon. Metal back-up rings offer superior radiation resistance when compared with non-metallic materials."

Aircraft Tires

Convair has made extensive studies of tire problems and reports the following: "Tires on high-performance aircraft are subject to pressure and temperature extremes on take-off and landing. Landing runout puts the most critical requirements on tires. No specifications are available which set limits on degradation of mechanical properties for tires. A conservative 25 per cent change in the properties of interest was arbitrarily set as the functional threshold in tests by B. F. Goodrich.

Based on mechanical property data, natural rubber blackstock seems suitable for the tire carcass. Natural rubber, improved by antirad compound IGFA26, offers high promise as a tread material. A blend of Hycar rubber, IGFA-10, and butyl rubber FR-150 appears a promising material for inner liners. Perlon, plus an antirad phenothiazene, or Dacron seems suitable for cord material. Functional thresholds for antirad-improved tires were about 9.0^9 ergs/gm(C).

Engine Fluids

In developing a radiation-resistant fluid, it did not take long to establish that conventional additives (anti-foamants and anti-oxidants) rapidly lose their effectiveness in a radiation field. Specific efforts were directed towards tailoring the chemical composition of the base fluid to an optimum behavior under conditions of elevated temperature, radiation, and oxidation. The polyphenyl ether fluids were found to show greatest promise. These have a useful temperature range 200°F above that of MIL-L-7808 jet engine oil. They are only 4 per cent as volatile and form only 1 per cent as much coke at 800°F. Oxidation stability is 1000 times greater.

The meta-isomers of the polyphenyl ethers allow for great versatility in fluid use. Some are ideal for jet engine oil (bis-m-phenoxyphenyl ether), some are ideal as hydraulic fluids (m-bis-m-phenoxyphenoxy benzene). Greases can also be compounded using polyphenyl ethers.

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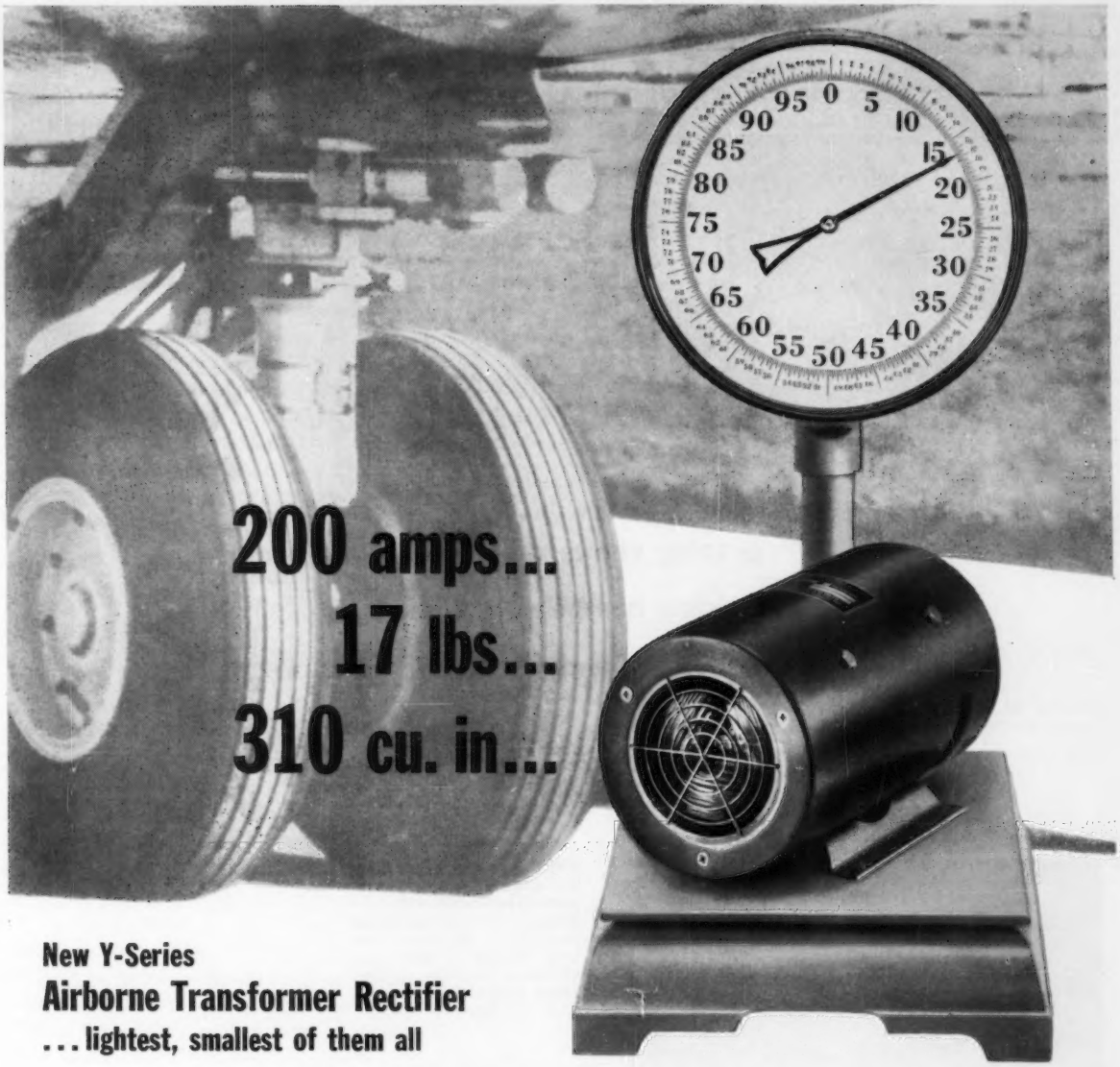
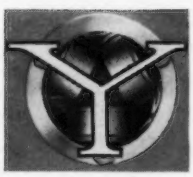


New Y-Series
Airborne Transformer Rectifier
...lightest, smallest of them all

But that's not all! To fit every aircraft design need, there are numerous other units in the revolutionary, new Chatham Y-Series Transformer Rectifiers which provide up to three-fold weight reductions over competitive models with comparable ratings. And because the new Y-Series combines the best component configurations in the smallest space, due particularly to the unique transformer 'Y' design, just ¼ the volume is required. These additional T-R miniatures in Chatham's across-the-board array are rated from 20 up to 200 amps and are proportionately lighter and smaller than the 200 amp unit. All units deliver 28 volts DC from 200 volt, 3 phase, 400 cycle aircraft power supplies.

Chatham's remarkable symmetrical 'Y' transformer coil configuration, aside from drastically slicing weight and volume, also minimizes possible spurious linkages and ripple voltage while keeping flux linkages uniform. These characteristics and the



quality components engineered into the 'Y' Series produce an extremely flat voltage output from no-load to full-load.

Yet with all this space-weight compression the Y-Series retains the built-in rugged dependability which has made Chatham the foremost manufacturer of airborne power conversion equipment. Use of Chatham's own silicon diodes and sturdy cast aluminum heat sinks is further indication that Chatham designed with reliability in mind. The new axial flow design featuring fan cooling offers maximum mounting flexibility but demands the very minimum in space requirements with considerable cost savings. Fan operation is guaranteed for 7500 hours with a minimum expected life of 10,000 hours at 71°C ambient.

The Chatham Y-Series answers your design problems especially when you're confronted with those tough aircraft space-weight restrictions. Write now for the new bulletin describing the Chatham Y-Series and other airborne power conversion equipment. Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, N. J. Sales Offices: Culver City, Calif., Dallas, Texas. TWX:NK193.

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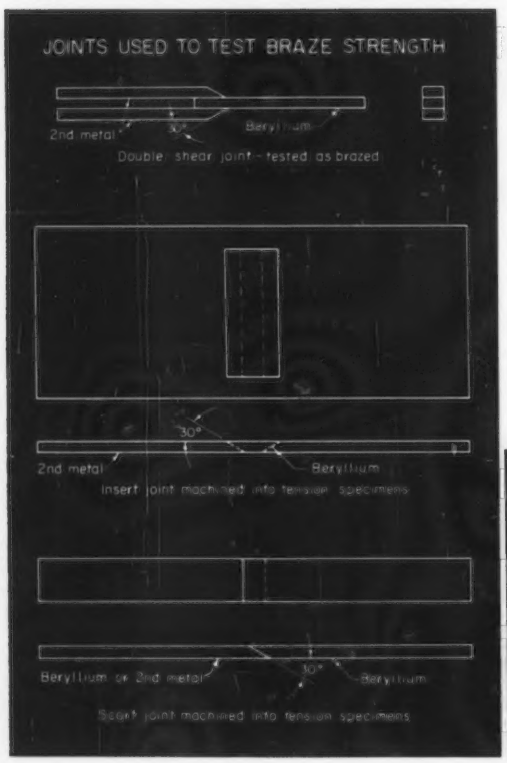
AIRCRAFT AND MISSILES

SPECIAL STAFF REPORT—PART II

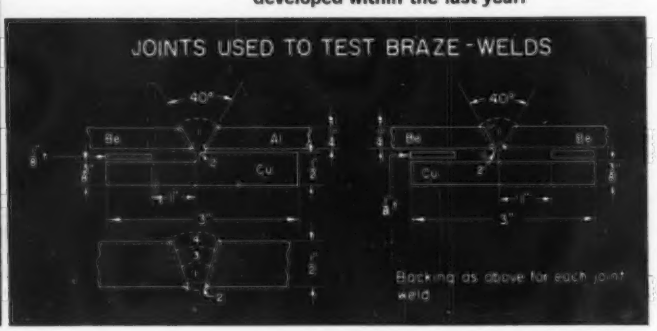
design tips for joining beryllium

brazing shows most immediate promise,
welding hampered by cracks,
adhesive bonding considered a possibility



Three types of braze joints are shown. Ordinary lap joints are undesirable because of inherent notch sensitivity. Beryllium has been brazed to itself, to stainless, to some of the super alloys all with good results.

In braze-welding, non-beryllium filler is added to the joint by arc or oxyacetylene torch. Joints used in some typical early tests are shown. Better results could be obtained with shielding techniques developed within the last year.



The characteristics of beryllium which make it difficult to fabricate into structural parts were discussed in part I of this report. Brittleness was mentioned as the outstanding obstacle. Brittleness also makes joining of structural parts difficult.

Techniques and Achievements

Disregarding mechanical fastening, brazing is probably the most widely used joining technique. Good, brazed joints are made with silver, and silver-copper eutectic alloy. Braze-welding with aluminum filler (12 per cent Si-Al) has also produced good joints. Resistance spot welds have been made, but little is known about the weld properties. Limited success has been reported with direct welding by tungsten-arc, pressure, and electron beam processes. Cracking is the major problem encountered. Adhesive bonding is considered a possibility.

Brazing

Furnace brazing has been accomplished with simple shapes. Silver and silver-copper brazing alloys are usually used. However, the aluminum, and silver-aluminum eutectic (28 per cent Al) have also been used.

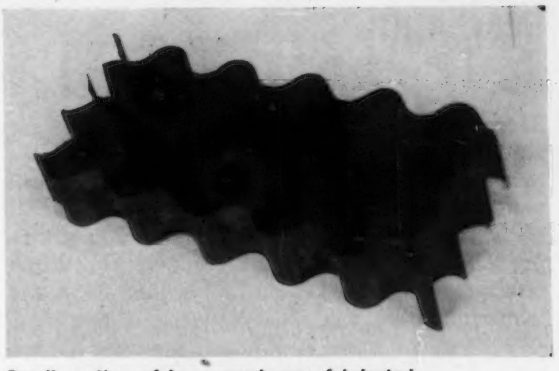
Joints must be cleaned (see tables). The braze material is placed in the joint and hydrogen, inert atmosphere, or vacuum introduced. Rapid heating and cooling cycles should be used to prevent intermetallic compound formation.

Time Is Critical

A critical factor when brazing beryllium to aluminum is the time at brazing temperature. If the joint is held too long at temperature, the braze material migrates away from the joint. Voids then form both at the interface and in the beryllium-base material. Higher brazing temperatures increase the rate of migration. Holding the joint at temperature for excessive periods of time will cause complete failure of the joint due to the formation of voids.

Normal brazing times cannot be used when silver or silver-copper eutectic alloys are used. The joint must be held at brazing temperature only long enough for the brazing material to melt and flow properly. Brazing can be carried out in a vacuum or in an atmosphere of hydrogen or an inert gas.

Dry hydrogen is required in brazing of beryllium to stainless steels if brazing is to be carried out in a gaseous atmosphere. The beryllium may oxidize slightly in any atmosphere, but both the silver and silver-copper alloy appear to wet the oxidized surface and good brazes are obtained. Beryllium has been brazed to 405 stainless steel, Hastelloy X, and Inconel X in a vacuum (1



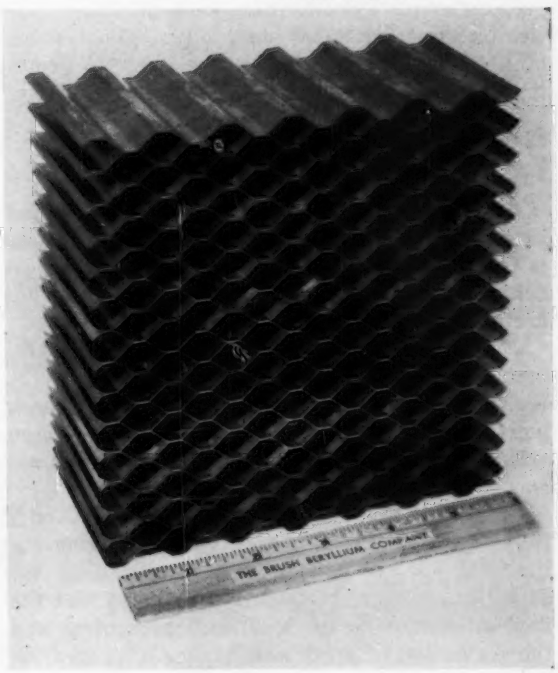
Small section of honeycomb was fabricated from beryllium foil 0.012 to 0.013 in. thick. One half inch cells are sine wave bonded with FM-47 adhesive. Density is 5.84 lb/ft³.

SURFACE PREPARATION FOR JOINING

Solution	Process	Time
Chromic anhydride (53 gm) Ortho- H_3SO_4 (450 ml) H_2SO_4 concentrated (26.5 ml)	140 °F Dip	1-3 min
also adequate		
HNO_3 (40 per cent) HF (2 per cent) H_2O (58 per cent)	Dip	2 min

Surfaces are prepared prior to etch by grinding and degreasing. Degreasing is done best with an acetone scrub, and rinse in absolute ether. Vapor degrease after grinding is unsatisfactory.

Recently, Brush Beryllium Co. demonstrated that large honeycomb sections can be made by resistance spot welding. Sciaky equipment was used to fabricate first test pieces.



micron of Hg pressure) using the silver-copper eutectic. Satisfactory brazes were made in the temperature range of 1435 to 1650°F. The lower temperatures are recommended to lessen the rate of diffusion between the beryllium and the brazing alloy, and the formation of weak, brittle intermetallics. Even with a vacuum of better than 1 micron of Hg, some oxidation of the beryllium surface occurs. Mechanical pressure applied to the joint also aids brazing by forcing contact between the brazing alloy and the base metal, and by forcing the excess filler metal from the joint.

Braze Joints

Lap joints are easiest to make but are not too reliable because of the inherent notch effect. Step joints, butt joints, and scarf joints should be used when possible.

Braze-Welding

In braze-welding, a non-beryllium base filler is added to the joint with an arc or an oxy-acetylene torch. Oxidation is less of a problem than in fusion welding because less heat is required.

Porosity seems to be the major problem using aluminum fillers. But, using 12 per cent Si alloy, shielding with helium, and using low welding current minimizes this problem.

Complete penetration, without discontinuities on upper or lower side, is essential because of notch sensitivity. Cracks are likely to propogate in the beryllium when discontinuities exist.

Joint designs are illustrated.

Fusion Welding

The literature contains little mention of consistant quality using fusion welding. Cracking is the most serious problem. Cracks appear just behind the molten pool. Oxidation and porosity are problems of lesser magnitude.

Brush Beryllium Co. has stated that preheating to 1000°F has given encouraging results. Welding was performed with tungsten arc under inert gas, using a beryllium filler rod. Preferred orientation of crystals at the point of the weld was completely lost.

Formation of the oxide in joints being fusion welded prevents wetting of the sides of the weld joint by molten weld metal. This oxide skin also covers the molten weld pool so that the flow of molten metal is difficult to control and the formation of good weld passes is prevented. Fluxes have been studied as a solution to this problem. Because of the low density of beryllium, solid fluxes sink through the molten beryllium and become entrapped in the weld rather than floating and protecting the weld pool. Active gas fluxes added to the shielding gas have helped overcome oxidation. Freon has been found most satisfactory for this purpose. A freon concentration of 1 per cent by volume prevents oxidation and reduces porosity. The active gases are very corrosive to the welding torch, and the decomposition products of freon rapidly attack the hot tungsten electrode. British investigators have found that a considerable amount of "cleaning" takes place (a) when direct-current reverse polarity (electrode positive) is used, and (b) on the positive half cycle when alternating current is employed.

Solid-State Welding

Solid-state welding has received attention because of the inability to produce reliable fusion and resistance welds.

Solid-state welds can be made in the temperature range from 1650 to 2280°F. Rather high pressures are required to produce welds at the lower end of the temperature range. As a result, most extensive study has been made in the 2010 to 2190°F range. No grain coalescence and little dispersion of inclusions occurs in 24 hr at 2010°F. Raising the temperature to 2100°F produces some grain coalescence and good dispersion in 24 hr. Best results are obtained at 2190°F. At this temperature, successful welds have been made in 1 hour and complete grain coalescence occurs in 2½ hr. These welds contain no inclusions. The best results are obtained when the welds are made in a vacuum, although welding can be carried out in an atmosphere of purified argon.

Beryllium surfaces to be joined by pressure welding must be flat and free of grease. Surface grinding has been found to be the best method of achieving a flat surface. Degreasing methods were described in a previous section.

Comparable tensile strengths have been found for pressure welds made at 2190°F and for beryllium basemetal treated at the same temperature.

✦

Based largely on a report from Defense Information Center, Battelle Memorial Institute. DMIC Memorandum 13.

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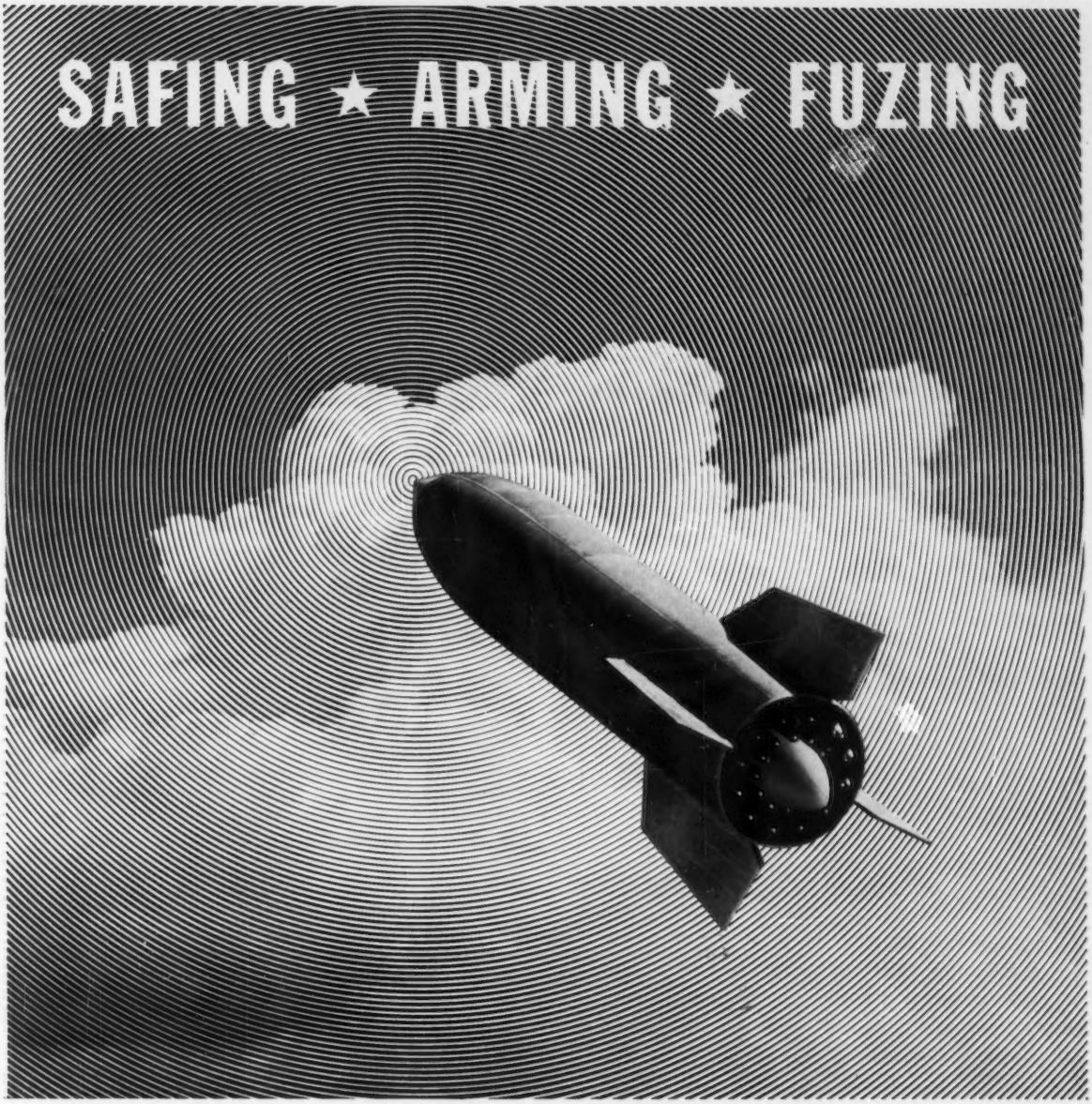

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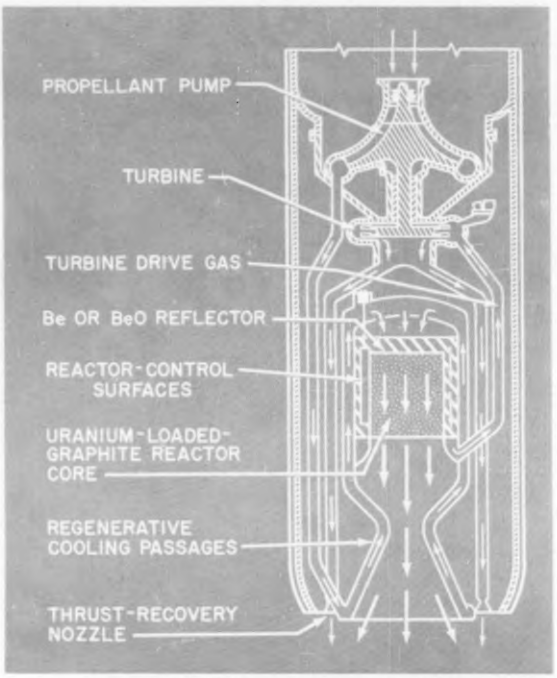
why nuclear rockets?

experts now see inevitability of atom power for big payloads and interplanetary range, specific impulse of chemical rockets near peak

by S. Peter Kaprielyan



Nuclear rocket configuration is shown, utilizing pressurized hydrogen as propellent. (Source: Levoy and Newgard, Reaction Motors Div., Thiokol Chemical Corp.)

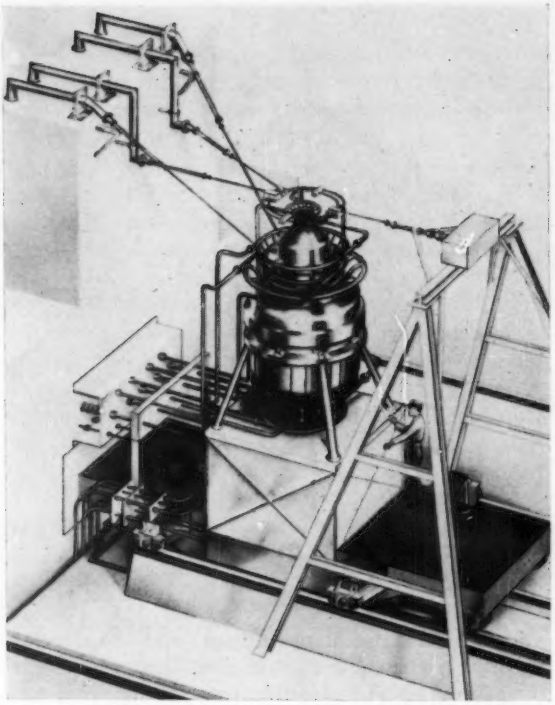
Five years of active feasibility studies "on a moderate scale," summarizes superficially our efforts in nuclear rocketry. Compared to the spectacular advances in chemical rocketry this does not sound very impressive. But, it constitutes the basic development of propulsion systems which will take over where chemical rockets leave off. Delay in initiating feasibility studies can not be attributed to a lack of vision by nuclear scientists, but to the customary pre-Sputnik apathy toward such projects.

In the astronautically-enlightened after-Sputnik era of today, most propulsion experts agree that the point of diminishing returns is already in sight for chemical rockets. After the multi-million-pound-thrust schemes now under study, new departures in energy utilization must be made. It is also agreed that among the numerous advanced propulsion schemes, nuclear powerplants will serve as work-horse systems.

In spite of the abundance of problems associated with such a project, AEC scientists are optimistic about the eventual outcome. They state they had known considerably less before embarking on the feasibility of nuclear fission itself. Although no official target-date has been announced, at this writing, estimates place the realization of nuclear-rocket propulsion close to ten years.

The Major Projects

Nuclear-rocket propulsion studies and associated research are currently under the joint



Artist's conception shows the Kiwi-A reactor set up for static testing.

jurisdiction of the Atomic Energy Commission and NASA. The major projects announced thus far are:

• PROJECT ROVER—A $26.1 million program to demonstrate the feasibility of nuclear rockets, being conducted at the Los Almos Scientific Laboratory (LASL). Major effort is to develop and build an initial ground-bound test device, Kiwi-A. This is a relatively low-power, experimental reactor with solid-fuel elements and a gaseous propellant. LASL is working only on reactor-propulsion systems, and not on the rockets or missiles such powerplants will eventually propel. One or more such reactors based on early design studies are to be tested at the Navada Test Site. Information gained here will help formulate more advanced concepts to be used in prototype nuclear-propulsion engines for rockets.

The first Kiwi-A was assembled without nuclear components by ACF Industries at AEC's South Albuquerque, N. Mex. works plant. It was reassembled with its nuclear components at the Nevada Test Site. Air Force work on certain non-nuclear components for Rover project were transferred to NASA. The nozzle for Kiwi-A was delivered to the AEC by the Rocketdyne division of North American Aviation (NAA) in January 1959. The Kiwi-A reactor was successfully tested late last spring.

• PROJECT PLUTO—A program to demonstrate the feasibility of a high-temperature air-cooled reactor for ramjets. It is being conducted at the Univ. of Calif. Lawrence Radiation Laboratory. In conjunction with Pluto, Atomics International, a division of NAA is investigating fabrication characteristics and physical properties of high-temperature metals, and the effect of fuel additives. A small-scale non-flyable reactor, Tory II, is also being tested at the Nevada Test Site.

• PROJECT ORION—An ARPA contract to General Dynamics Corp. for a feasibility study of controlled nuclear-pulse propulsion.

Why Nuclear Rockets

Consideration of nuclear rockets is not aimed at replacing chemical rockets for missions in the vicinity of the Earth.

The usefulness of chemical rockets will probably extend for several decades, as basic power-plants, and for unmanned exploration of the near planets. To explore what lies beyond, the nuclear rocket offers the best possibilities.

Use of nuclear reaction for rocket propulsion places almost unlimited energy at man's disposal. A crude analogy would be to compare the energy yield of chemical explosives to that of the atom bomb. This kinetic energy, translated into the directed momentum of combustion products is measured by the yardstick of specific impulse. Simply stated, specific impulse (Isp) is the effective exhaust velocity of propellant divided by acceleration of gravity. This represents the pounds of thrust produced per pound of propellant flowing through a nozzle, per second.

Two factors control the exhaust velocity of propellants: combustion temperature, and molecular weight of combustion products. Exhaust velocity can be increased by increasing combustion temperature, or by using propellants with light-weight combustion products. The combustion temperatures of current chemical rockets are about 5000°F—sufficient to consume most materials available today. Attempting to increase

combustion temperature, therefore, offers no immediate benefits. Since the second alternative offers greater possibilities, hydrogen is considered as a propellant for being the lightest of elements.

In simple theory, to attain high specific impulse we replace chemical-rocket combustion by a nuclear reactor, and heat hydrogen to maximum temperature allowable by materials. In practice, this means that reactors will be expected to operate at power densities much higher than present reactors. One estimate, by Levoy and Newgard of Thiokol Chemical Corp., anticipates power requirements to be 100 times more, from a core 30 times smaller, than reactor at Calder Hall, England. This reactor has a cylindrical core 31 ft in diam and 21 ft long; its core power-density is 11.5 kw/ft^3.

In the idealized concept, a "miniaturized" and "super-power" reactor would be used to raise the temperature of liquid hydrogen from —423°F, convert it to a gaseous state, and expel it at temperatures 2500 to 4000°F. If operation at such temperatures can be maintained, even though only for a few minutes, specific impulses up to 1200 sec can be attained. This is about three times the highest specific impulse obtainable through chemical fuels. Thus, even the lower operating-temperatures would produce a specific impulse of 600 to 800 sec still excelling the chemical rockets.

Design Problems

There is obviously much ground to be covered before the Kiwi-A test reactor gives birth to an airborne successor. The following are some of the principal engineering problems to be solved:

- Reactor controls must be made capable of bringing the reactor safely up to operating power within a matter of seconds. Hence, provisions must be made to program the reactor through rapid changes in power.

- Methods must be provided to reduce heat from neutron and gamma radiation in adjacent engine compartments and propellant tanks. Light-weight yet effective shielding materials must be developed to limit induced radioactivity in adjacent structural elements.

- Consideration must be given to the fact that fission products will be carried by the propellant into the exhaust stream, producing radioactivity in surrounding area.

- Reactor materials will be required to operate at very high temperatures, without erosion, corrosion, or change in physical characteristics.

- Since the operational temperatures of the reactor will tax the endurance limits of materials, regulation of coolant (or propellant) flow will be critical.

- Special design considerations result from strong temperature gradients existing within the reactor. These variations depend upon startup rate, length of run, hydrodynamic characteristics etc.

Although hydrogen is an attractive working fluid, due to its low molecular weight, it has its drawbacks. Hydrogen embrittles some materials, forms hydrides with others (with resultant corrosion) and forms volatile hydrogen compounds with others (thus eroding the material). Materials must also withstand stresses resulting from temperature changes and acceleration loads. Graphite, tungsten, tantalum, molybdenum, niobium, rhenium, zirconium, and hafnium are presently under investigation. In many cases carbides, nitrides, and borides of these and other elements with desirable properties are also being studied.

As summarized by Dr. R. Schreiber of the Los Alamos Lab, "The design of a reactor involves a series of compromises; and the development of a nuclear rocket evolves through a series of interdependent considerations going from neutronics, to materials, hydrodynamics, controls, and back to neutronics in a succession of approximations."

It would probably be an understatement to say that nuclear-rocket propulsion is beset by enormous technological problems. Project Rover studies are directed to the systematic solution of many of these unknowns; fundamental knowledge thus gained will pave the way for more advanced concepts presently in their ultra-theoretical stage. Among these concepts are the molten-fuel-type reactor through which the working fluid (hydrogen) may be bubbled, and the gaseous-core reactor which may use a nuclear fuel in the gaseous (plasma) state. Hybrids and ramifications of these concepts are also in the offing.

✦

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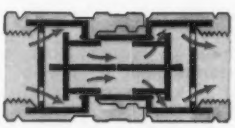

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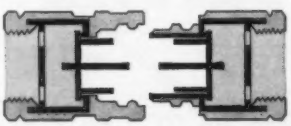

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Russia's nuclear aircraft

many configurations studied, design now beyond theoretical boundaries; prototype construction underway

This article is a condensed version of a Russian manuscript entitled, "Atomic Energy in Aviation." Author is Yu. N. Sushkov. Translation was done by General Electric Co., Aircraft Nuclear Propulsion Dept.

When discussing the application of atomic energy in aviation, several questions arise:

- Are atomic aircraft engines necessary at all?
- Do they have any advantages over ordinary engines?
- Is it possible to build reliable and non-hazardous atomic engines for aircraft?

Only by using nuclear fuel can the problem of long flight-range at supersonic speeds be solved.

Nuclear fuel consumption would be 2 million times smaller than the consumption of kerosene in conventional aircraft. An aircraft weighing 100 to 150 tons would consume only 500 grams of uranium-235 in a round-the-world flight at 2000 km/hr.

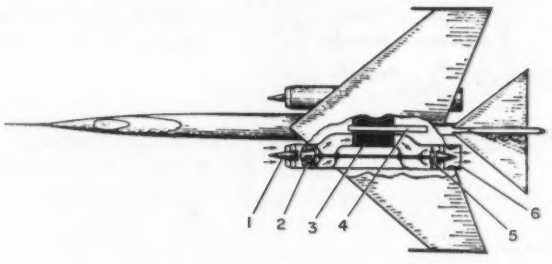
The Basis of Nuclear Power

Nuclear power is obtained by fission of nuclei in isotopes of some heavy elements. These isotopes are: uranium-235 found in natural uranium in the amount of 0.7 per cent; artificially-produced uranium-233; and plutonium-239.

This is how the fission reaction proceeds in uranium-235. A free or so-called "wandering" neutron impacts a nucleus of uranium-235 and imparts energy to it. The nucleus becomes excited and unstable. In most cases it fractures. At the moment of fracture 2 to 3 new neutrons are released. These are called secondary neutrons. If the piece of uranium is of sufficient size, each of the secondary neutrons can impact another uranium nucleus and cause new fission. This process continues, and under controlled conditions the fission reaction can be self-sustained. Reactions of this type are called chain reactions.

Speed of the fission fragments, immediately after fracture, is equal to 10,000 to 15,000 km/sec. The fragments impart energy to the surrounding atoms, increasing the speed of their random movement. This increases the temperature and nuclear energy is released in the form of thermal energy.

Fig. 1. General view and schematic of an aircraft with two atomic turbojet engines: (1) inlet cone, (2) compressor, (3) reactor, (4) control rod, (5) turbine, (6) jet nozzle.



Therefore, all contemporary atomic-power installations utilize heat engines—steam or gas turbines.

The Direct Cycle System

Fig. 1 shows a schematic of an airplane with two atomic turbojet engines operating on the direct-cycle principle. The reactor replaces the combustion chamber. The air which is heated in the reactor is returned to the turbines. After passing through the turbines, the air is ejected out through the jet nozzle at high speed to create thrust.

Inlet cones, shown on the schematic, are placed in front of the engine to decrease the intensity of the shock waves which occur at supersonic speeds; shock waves decrease propulsive efficiency.

Supplying air to the reactor requires tremendous ducts and makes the arrangement of atomic powerplants on an aircraft inescapably difficult. In order to heat the air in the reactor, a large heat-exchange surface area is required: about 800 to 1000 sq meters for an aircraft with a flying weight of 100 to 120 tons. Thus, the reactor is forced to large dimensions. This of course, results in an increase of aircraft weight and a decrease in its flying speed for a given power.

Indirect Cycle

Heating the air in an atomic turbojet engine may also be accomplished indirectly in a heat exchanger, with the aid of a metallic heat-transfer agent (Fig. 2). The heat-transfer surface required to heat the liquid metal is many times smaller than the surface required to heat the air directly. The reactor can therefore be smaller and lighter. But the weight of the heat exchanger and the heat-transfer medium add to the weight of the engine. Whether an engine with the air heated directly in the reactor, or with the air heated indirectly in a heat exchanger, is more advantageous depends on the flying weight of the aircraft and its designed flight speed. The indirect system is especially favorable in multi-engine aircraft, since the operation of more than one engine is possible from a single reactor.

Increasing Thrust

Part of the energy of the heated air is lost in the turbine; therefore, the air temperature behind the turbine is 150 to 200°C lower than in front of the turbine. The air exit speed from the jet nozzle, and accordingly the thrust, depends on the air temperature in front of the nozzle. The higher the air temperature in front of the nozzle, the higher is the propulsive thrust. Therefore, it is advantageous to heat the air additionally behind the turbine.

The simplest way to do this is to place an additional heat-exchanger between the turbine and the jet nozzle. The heat-transfer medium from the reactor first passes into the additional heat-exchanger, gives up some of its energy to the air flowing into the nozzle, then returns to the original heat-exchanger to heat the air just being directed towards the turbine.

In this system the coefficient of useful turbine action is lowered and the nuclear-fuel consumption is increased. But, since consumption of nuclear fuel is very small, lowering the turbine efficiency is made up by an increase in propulsive thrust.

Another way to increase the air temperature in front of the jet nozzle is to use a steam or gas turbine instead of a compressor. This turbine would not use the thermal energy from the air heat exchanger; therefore, the velocity of the air exhaust from the nozzle and consequently the propulsive thrust would increase.

Fig. 2. Schematic of an atomic turbojet engine with liquid-metal heat-exchanger: (1) reactor, (2) control rod, (3) liquid-metal pump, (4) heat exchanger, (5) inlet cone, (6) compressor, (7) jet nozzle.

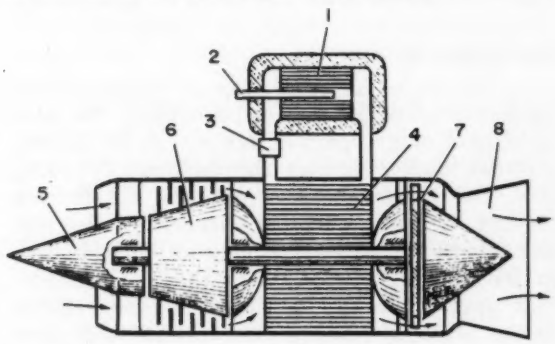


Fig. 3. Schematic and general view of an aircraft with two atomic compressor-drive engines: (1) inlet cone, (2) air compressor, (3) gas turbine, (4) gas compressor, (5) heat exchanger, (6) jet nozzle, (7) nuclear reactor, (8) control rod.

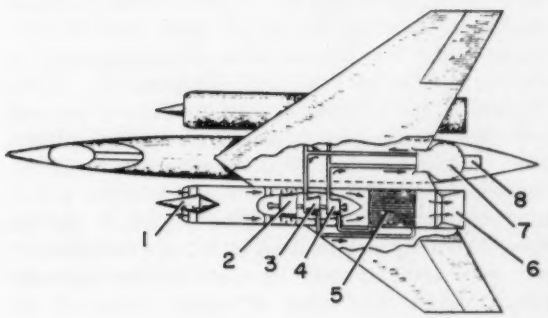


Fig. 4. Schematic of an atomic turboprop engine with mercury turbine: (1) propellers, (2) reduction gear, (3) air compressor, (4) mercury turbine, (5) reactor, (6) control rod, (7) mercury pump, (8) condenser, (9) jet nozzle.

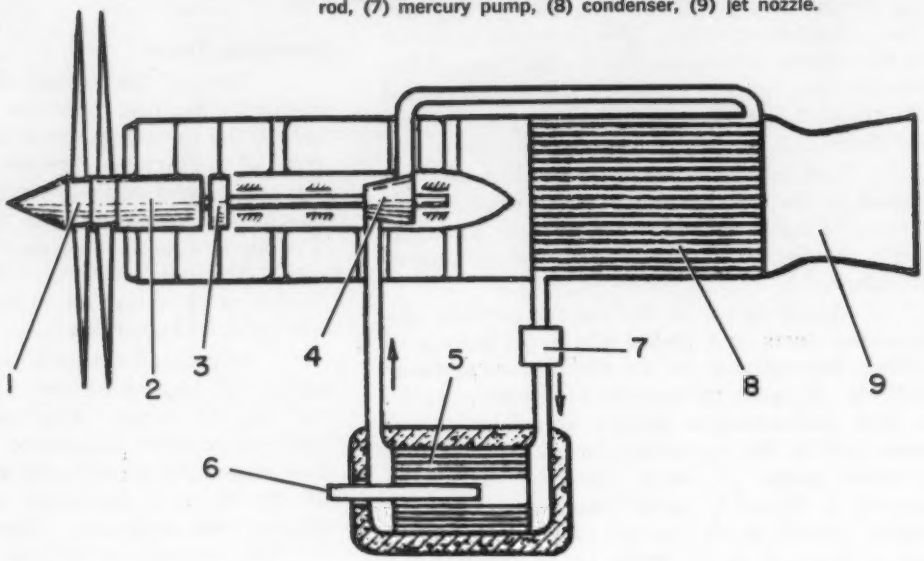


Fig. 3 is a schematic of an aircraft having two atomic engines with the air compressor driven by a helium turbine.

The power ratio is approximately as follows: If the power of the helium turbine is 150,000 hp, then 100,000 hp is used by the helium compressor and 50,000 hp by the air compressor. The efficiency of such an arrangement is not high.

Mercury-Vapor Turbine

Power requirements are less when the air compressor is operated by a mercury-vapor turbine. Mercury is changed into vapor in the reactor, then is directed to the turbine which is connected to the air compressor by means of a shaft. The vapor flows from the turbine to the condenser-heat-exchanger. Upon condensing into the liquid mercury, the vapor heats the air. Because of the low temperature of condensation of mercury, even at the increased pressure in the condenser, the propulsive thrust will be somewhat less than in the case of a helium turbine. However, the nuclear-fuel requirements will be lower, because, instead of the 150,000-hp turbine, a turbine of only 55,000 hp will be required. As before, 50,000 hp will be used by the air compressor, but only 5000 hp will be used by the mercury pump. If the coefficient of useful action of the steam turbine is the same as for the gas turbine, then the decrease in steam-turbine power-requirements will also result in a decrease in reactor power, for the same propulsive thrust. But as a rule, the coefficient of useful action of a gas turbine is much greater than for a steam turbine. Therefore, the economic gain from the decrease of steam-turbine power is lost to a significant degree, and the resulting reactor-power for both engines is about the same. When comparing the drive of an air compressor by gas and mercury turbines, it should be kept in mind that it is much more complicated to build a reliable reactor where mercury is changed into vapor than it is to build a gas-cooled reactor.

The Turbine Bypass

There is one more way of increasing the air temperature in front of the nozzle. The idea is to pass only a part of the air of the atomic turbojet engine through the turbine. By doing this, the thermal energy of the air flowing through the turbine will be considerably lowered, and it will not be able to play an effective role in the creation of propulsive thrust. However, that part of the air which enters the exhaust nozzle after by-passing the turbine will have

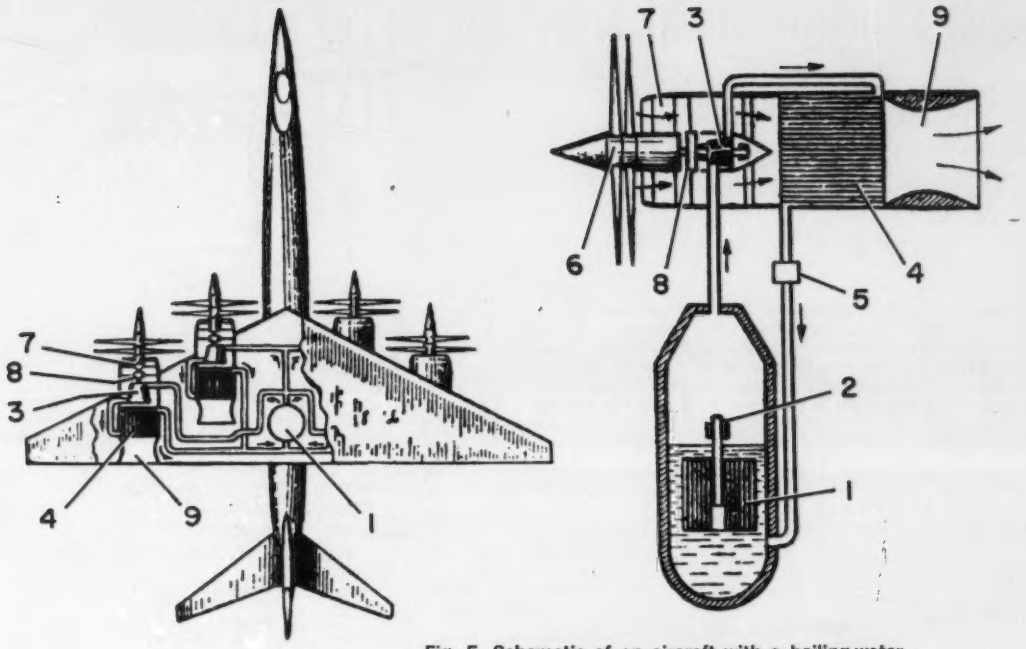


Fig. 5. Schematic of an aircraft with a boiling-water reactor and steam-turbine engines: (1) boiling-water reactor, (2) control rod, (3) steam turbine, (4) condenser, (5) water pump, (6) propellers, (7) reduction gear, (8) air compressor, (9) jet nozzle.

the same temperature as air in the reactor or the heat exchanger. Therefore, the velocity of the exhaust from the jet nozzle will be greater than in the case where all the air flows through the turbine. Thus, the propulsive thrust will increase.

The Turboprop

An atomic turboprop-engine differs from an atomic turbojet only by the presence of a propeller and reduction gears. Since the turbine of such an engine must be much more powerful than the turbine of a turbojet, it should be multistage. It is possible to utilize steam or gas turbines in the atomic turboprop. An air compressor is required only to force air through the condenser heat-exchanger. Fig. 4 shows the schematic construction of an atomic turboprop engine with a mercury turbine.

A "boiling water"-type reactor is shown on an aircraft which has steam-turbine atomic turboprop engines in Fig. 5. This type reactor consists of a thick-walled pressure-vessel containing ordinary water. A grid of enriched uranium rods, encased in zirconium, is placed in the water. The evolved heat converts the water into steam. A steam separator is located either in the upper part of the reactor or above the reactor. It separates small water-particles from the steam and returns them to the reactor. The steam is ducted to the engines' steam turbines. After being used, the steam passes into a condenser, is cooled by a stream of air, is condensed to water, and is again pumped into the reactor. The turbine drives the propellers through reduction gears.

The Ramjet

The application of atomic energy in other kinds of aircraft engines is also possible. Fig. 6 is a schematic of an airplane having two atomic ramjets located above the fuselage, and one atomic rocket-engine located in the fuselage. The ramjet engine is essentially a "flying reactor" to which an inlet diffuser, which directs a supply of air to the reactor, is attached at the front. Behind, there is a jet nozzle through which hot air is discharged at a greater velocity than the velocity of the airplane. Propulsive thrust is created because of the difference between the inlet and exhaust velocities of the air. The fault of a ramjet engine, either atomic or ordinary, is that it can increase its propulsive thrust only at high speeds. Therefore, an aircraft must have some other engine besides the ramjet in order to take off and accelerate.

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Russia's nuclear aircraft...

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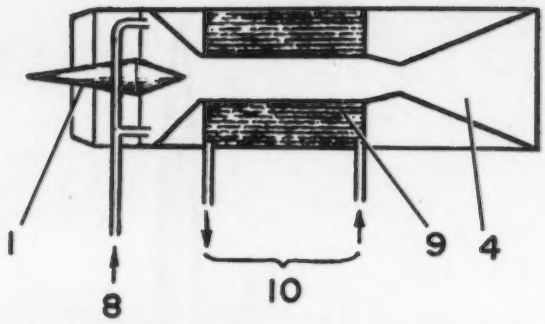

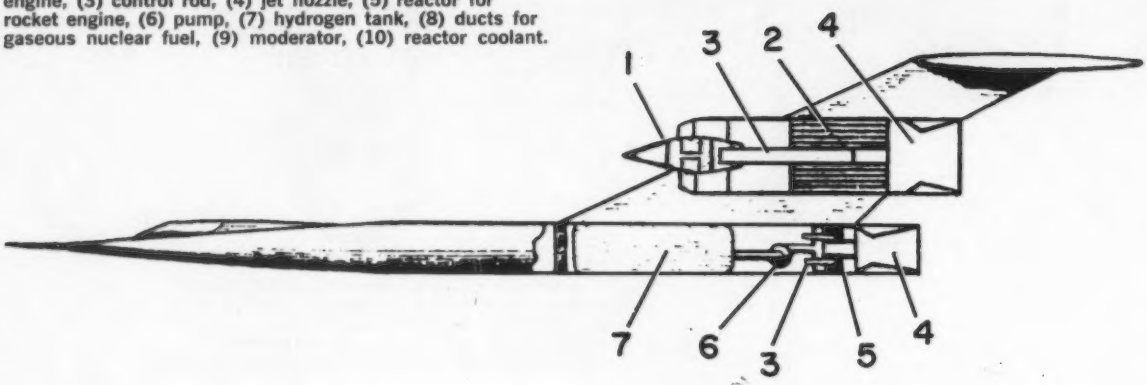

Fig. 6. General configuration and schematic of an aircraft with two atomic ramjet and one atomic rocket-engine: (1) inlet cone, (2) reactor for ramjet engine, (3) control rod, (4) jet nozzle, (5) reactor for rocket engine, (6) pump, (7) hydrogen tank, (8) ducts for gaseous nuclear fuel, (9) moderator, (10) reactor coolant.

If an atomic ramjet engine should operate on gaseous nuclear fuel, the air which is mixed with this gaseous fuel is directed into the reactor cavity. There, the nuclear reaction takes place and as a result the air is heated. Then the air passes on out through the nozzle. The reactor in this engine is a powerful source of neutrons. Naturally, this is accompanied by the liberation of heat. This heat must be removed from the reactor and can be used for the operation of the turbine on any other engine installed on the aircraft. The possibility of using this type engine depends on the quantity of gaseous nuclear fuel that is consumed. Calculations show that at neutron flux densities in the reactor which are possible at the present time, the probability of neutron collision with the gaseous nuclear fuel nuclei is very small. To achieve the required heating of the air in the engine, the consumption of gaseous nuclear-fuel would be very large. Therefore, it is not practical to build such an engine.

Development Status

Schemes for aircraft atomic-engines described here, of course, do not cover all variations possible; however, they show some of the possible design concepts.

It is possible to build an atomic powered airplane. The atomic engines, the reactor, and protective shield would not weigh more than certain conventional aircraft with full fuel. Minimum flying-weight of an aircraft for which these conditions hold, would probably be 90 to 100 tons. The payload would be 5 to 10 tons, and the aircraft would thus be able to transport 50 to 100 passengers.

When should the first flight of an atomic airplane be expected. What are the practical achievements in the areas of application of atomic engines in aviation?

Progress on the construction of an atomic airplane is beyond purely theoretical boundaries and has passed into the experimental phase, construction development, and experimentation with separate components. We are at the threshold of the next phase—the construction of an experimental prototype.

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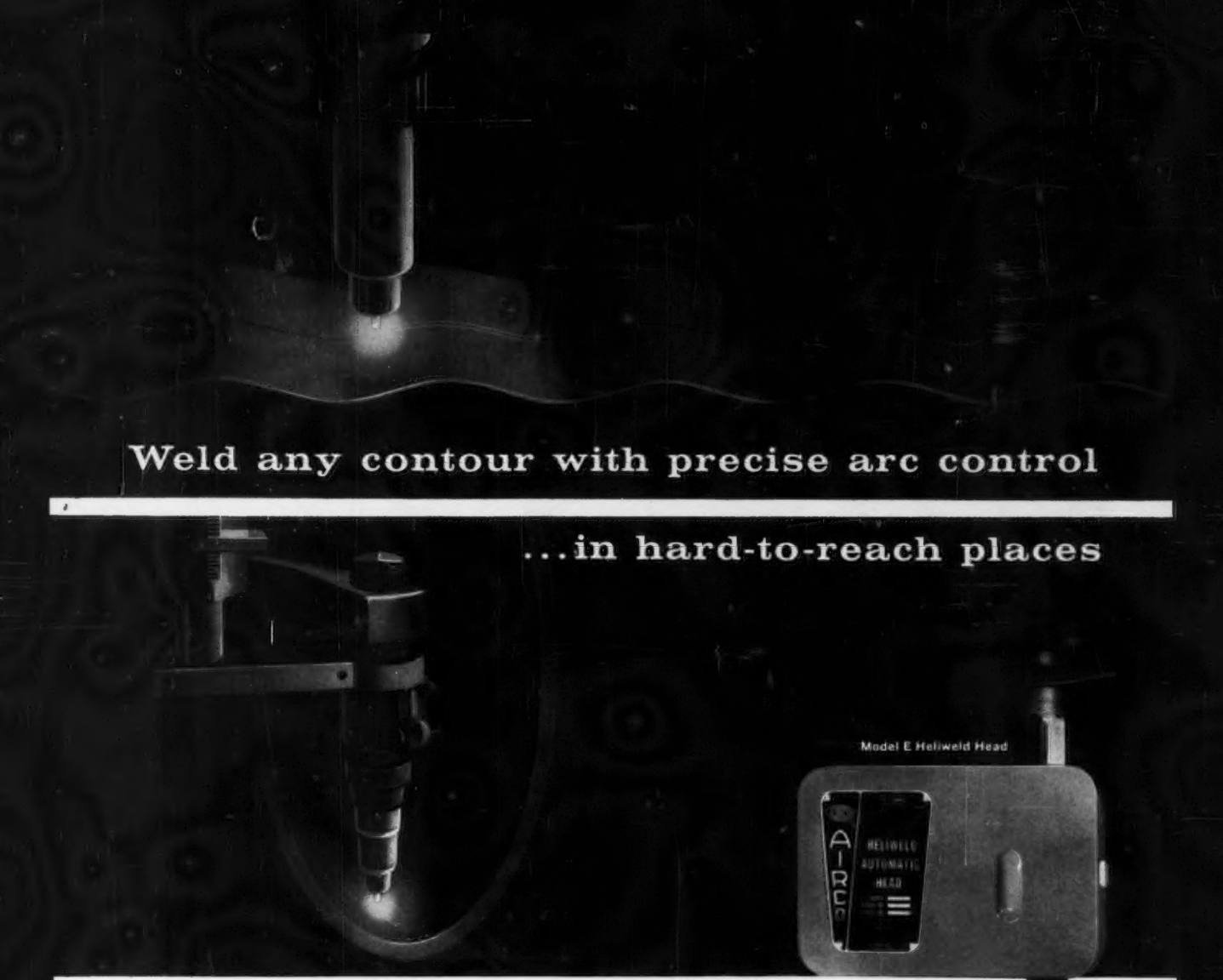

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Circle 13 on Inquiry Card

printed circuits

Now deployed in Europe, TM-76A Mace uses ATRAN map-matching guidance. Inertial guidance units can be substituted with minor changes in production phase.

by John P. Kushnerick

proposed redesign of gyro shelf incorporates printed circuit in honeycomb panel; savings in time, weight, space result, field maintenance eased

Combining printed circuits and honeycomb sandwich panels make possible three eternally sought savings in electronic devices. Savings in cost, weight, and space.

A proposed redesigned of the gyro-shelf in the Mace guidance section uses this concept. A "standard" printed circuit board serves as one face of a honeycomb panel. The panel thus doubles as the support structure of the electronic package and as circuit board.

Studies by the Producibility Group at Martin indicate this redesigned structure gives:

- Weight saving of 3 lb.
- Time saving of 40 hr/unit in wiring.
- Increased reliability by reducing number of parts.
- Easier field maintenance.
- Shielding at least equal to normal shielded wire up to 20 kc.

Savings are great enough to allow costs of redesign to be absorbed in first 22 units.

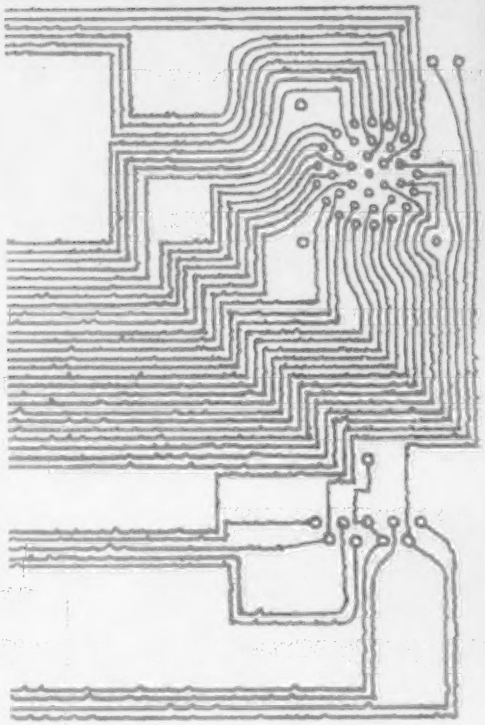
Materials of Construction

The prototype panel is constructed of plastic skins, adhesively bonded to a glass fabric core.

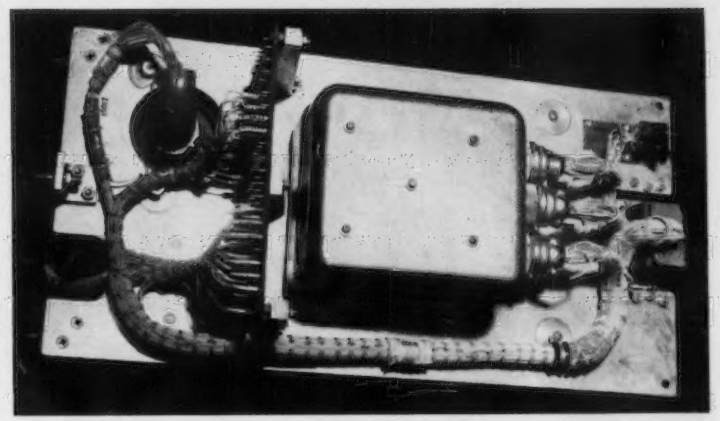
PRINTED CIRCUIT BOARD which serves as one face of the honeycomb panel is manufactured

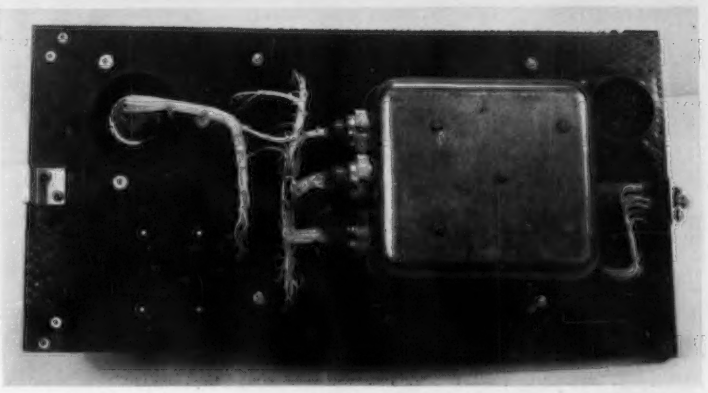
in Mace guidance

By incorporating printed circuitry into support structure of electronic unit, Martin can save 3 lb. Wiring time is reduced 40 hr/unit.



ORIGINAL DESIGN





REDESIGN

to a standard Martin Spec (P-85035). Other skin is a lamination of glass fabric and epoxy resin.

CORE is Hexcel's CTL ¼ in.-cell, glass-fabric honeycomb. Core is filled with Corefil 615 in areas that receive attach bolts.

BONDING AGENT is Bloomingdale Rubber Co.'s FM-47 liquid and film. Adhesive liquid is spray coated on faces, roller coated on core, and force dried.

CURING the sandwich is effected in a heated platen press. Cycle includes a preheat at platen contact pressure, and a final cure at higher pressure.

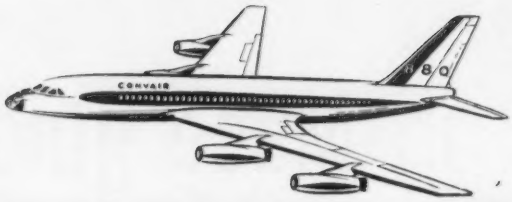
Testing

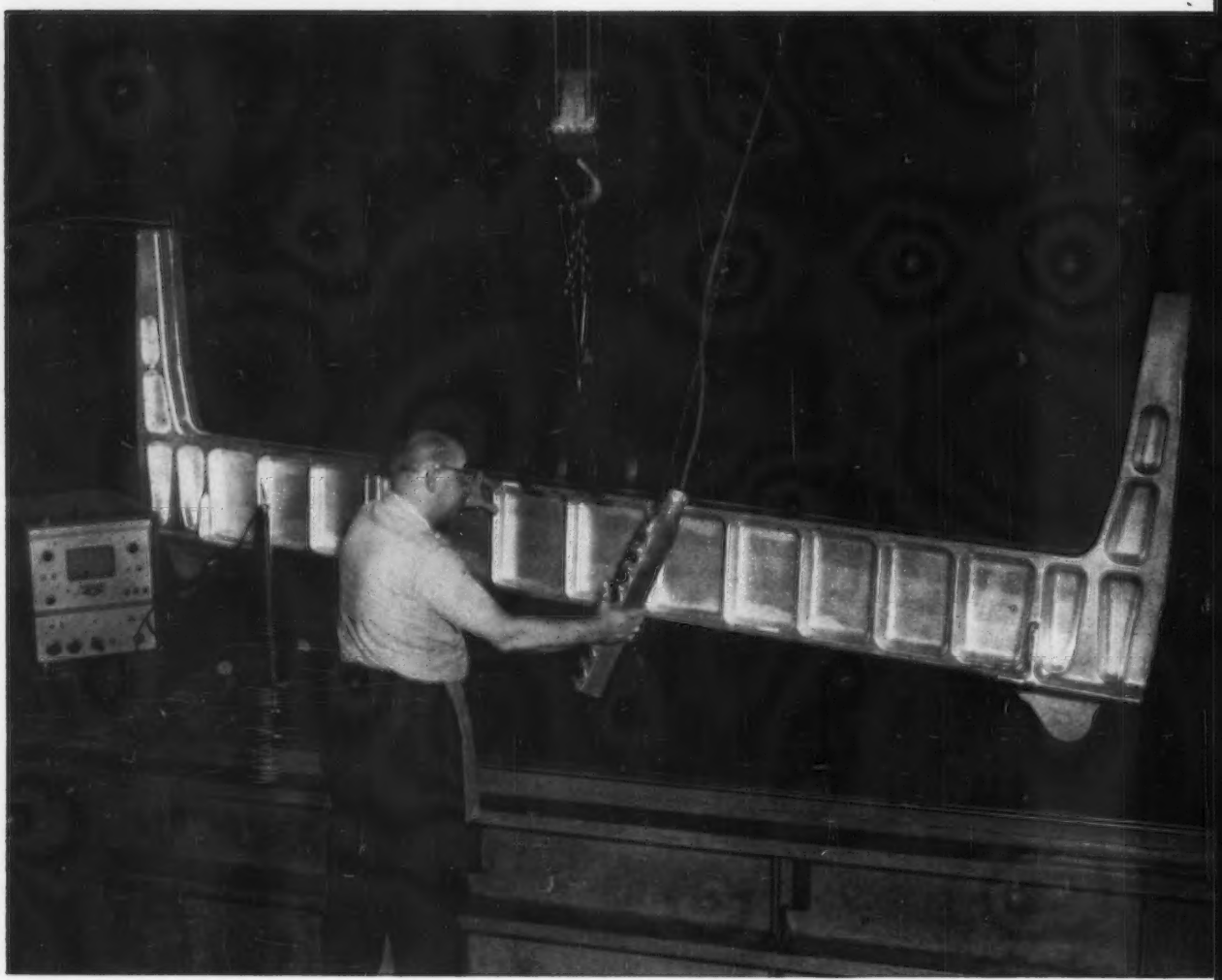
Panel has been flex tested at —67, 80, and 160°F under 230 lb. Loading rate was 100 lb/min. This was to simulate a 13 g load. No structural failure or damage to printed circuit occurred.

Humidity tests (100 per cent) were run at —70, 80, and 180°F with no apparent adverse effects.

Shielding of the printed circuit against radio noise was evaluated up to 20 kc, and found at least as effective as normal shielded wire.

A Patent application covering this development is pending.

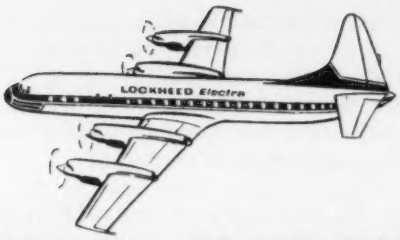


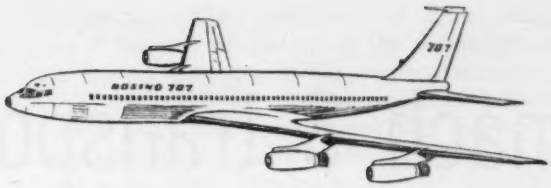


Largest closed-die forging ever made for commercial aircraft

The forging of these 657 lb. bulkheads presented unusual problems—problems of die design, of forging, and of handling. The successful solution of these problems saved a costly assembly of many smaller parts—costly both in terms of dollars and pounds.

This is a typical Wyman-Gordon accomplishment —the result of over seventy-five years of forging experience, and today supported by the greatest range of heavy forging equipment and technical know-how in the industry.

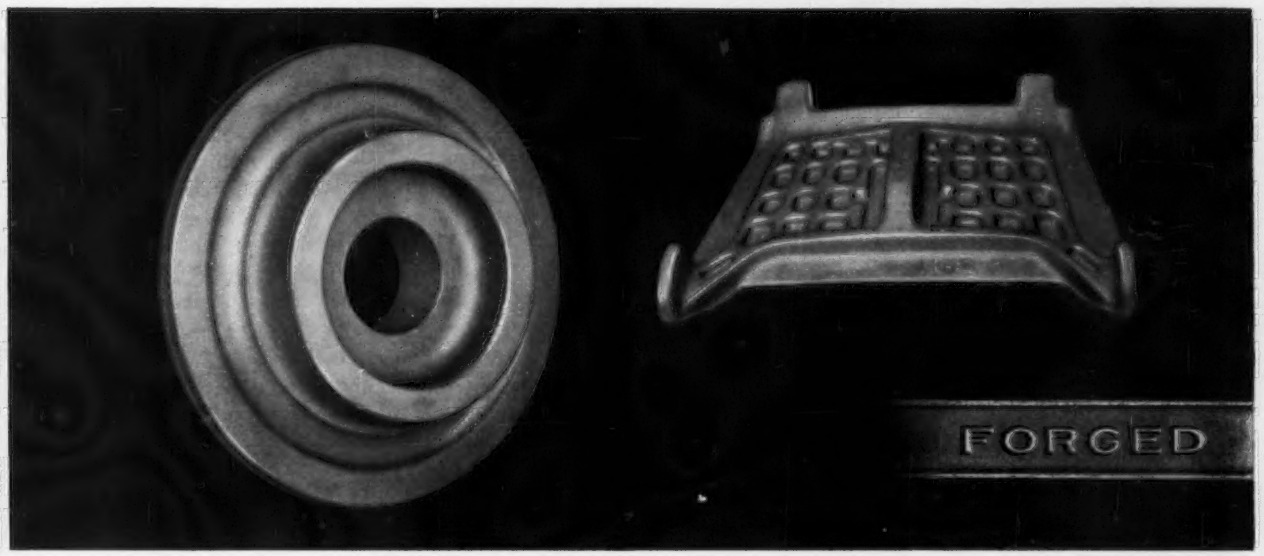




Over 1000 Wyman-Gordon forgings pace advanced jet designs

In saluting the great achievement of America's commercial jet leadership, Wyman-Gordon takes great pride in having participated so extensively in the development of the aircraft industry from its very beginning.

In World War I, the use of forgings was confined to engine parts and Wyman-Gordon made most of them. Today, from the huge main bulkhead forging at the left to the engine parts below, Wyman-Gordon forgings are in the wings, fuselage, landing gear and engines of the four newest commercial jet aircraft. These and a great variety of other vital components are forged from many types of materials: aluminum, magnesium, titanium, steel, as well as many new uncommon alloys.



EST. 1883

In the highly stressed parts of modern aircraft, there is no substitute for forgings and in complicated forgings of difficult alloys, there is no substitute for Wyman-Gordon quality and experience. We are prepared to serve you at the design, engineering and purchasing stages of your developments.

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of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

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GRAFTON MASSACHUSETTS FRANKLIN PARK ILLINOIS LOS ANGELES CALIFORNIA FORT WORTH TEXAS

mach 3 transport

will it be rocket powered?

by J. M. Cumming, program manager, small engine systems
Rocketdyne, Div. of North American Aviation, Inc.

There appears to be a strong trend toward the theory that the Mach 2 transport will be bypassed in favor of the Mach 3 to 5 transport.

A generic airframe design selected for study of various types of Mach-3 propulsion units is illustrated. A typical 1959 turbojet airliner is compared in Table 1 with the assumed Canard configuration. The high cost of fuel for climb and acceleration led to the conclusion that considerations for the supersonic transports should be confined to trips over 2000 nautical miles with longer ranges for the higher Mach numbers. Using this data, powerplant combinations were sought that would give the most practical operation in line with factors such as availability, operating know-how, and handling problems. Data on the various types of power plants considered are summarized in Table 2.

Use of air-breathing engines for the cruise and final portion of flight appears optimum for the present state-of-the-art. This is particularly true if a ducted arrangement is used to increase their efficiency. However, for climb and rapid acceleration to reach the high Mach number cruise speed, the rocket engines were advantageous in each case. No precise, analytical solution was attempted in this study because of the difficulties of predicting aerodynamics criteria for future aircraft. However, in making relative comparisons, it was generally concluded that the use of a rocket engine such as the present S-3 with 150,000-lb of thrust combined with two turbojets using afterburners to produce an over-all total of approximately 154,600 lb of thrust during climb, would provide an economical take-off, climb and acceleration for a transport of the period beginning in 1965. For those that prefer the multiple rocket engine concept, two Rocketdyne S-4 engines of 60,000-lb thrust each, would serve admirably as well.

The rocket engine installation in such a transport is shown. Also shown is a possible flight envelope utilizing the method of gradual exchange of potential energy (altitude) for kinetic energy (speed) to attain the desired range. Ducted turbojets appeared as efficient means of allowing a low over-all rate of descent in cruise, while maintaining the necessary acceleration potential

Table 1. Comparison of Subsonic and Supersonic Transports

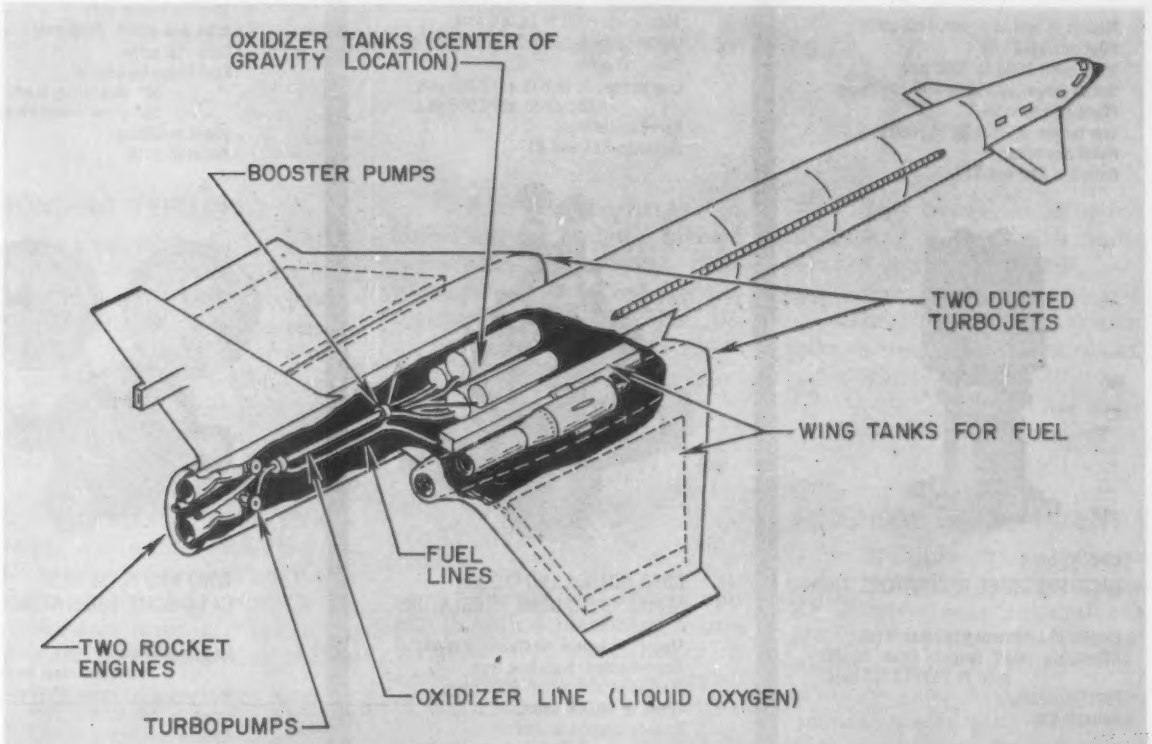
PRELIMINARY ESTIMATES	1959 TURBOJET AIRLINER	1965+ CANARD CONFIGURATION WITH MIXED POWER
TAKE-OFF WEIGHT, LB	290,000	400,000
LANDING WEIGHT, LB	192,000	230,000
MAXIMUM RANGE, MI	5,500	5,000
AVERAGE WING LOADING, LB/FT^2	100	85
AVERAGE CRUISE ALTITUDE, FT	40,000	70,000
AVERAGE CRUISE MACH NO.	0.8	3.5
AVERAGE CRUISE SPEED, MI/HR	580	2,270
AVERAGE L/D RATIO	14	7
SPAN, FT	141	110
LENGTH, FT	151	175
EXPECTED PAYLOAD, LB	37,000	50,000

Table 2. Typical Data for Aircraft Powerplants

POWERPLANT	SPECIFIC WT, PERCENT		THRUST, ENGINE WT, PERCENT		THRUST, LB FRONTAL AREA, FT^2		SPECIFIC FUEL CONSUMPTION	
ALTITUDE	SEA LEVEL	50,000 FT	SEA LEVEL	50,000 FT	SEA LEVEL	50,000 FT	SEA LEVEL	50,000 FT
TURBOJET WITHOUT AFTERBURNER	0.40	2.20	2.50	0.46	1800	328	1.20	1.10
TURBOJET WITH AFTERBURNER	0.23	0.78	4.30	1.28	2800	835	2.30	2.10
RAMJET	0.11	0.26	9.10	3.78	3000	1250	4.50	3.00
DUCTED TURBOJET	0.25	0.42	4.00	2.40	1800	515	0.98	1.20
AIRCRAFT ROCKET	0.022	0.016	45.00	63.00	15400	21700	16.00	14.00

for regaining altitude for the consecutive "altitude-speed-range" trade-off.

It is realized that previous studies have concluded that a two-stage aircraft with a rocket boost in the first stage and a turbojet or ramjet in the second stage was the most practical approach to supersonic or hypersonic commercial flying. However, it is the author's opinion that this is too great a step and the economy it may bring about in fuel consumption is insufficient to outweigh the psychological and operational problems involved in the two-stage propulsion system. Because the initial rocket boost consumes a large part of the over-all weight of the rocket propulsion system, and due to the relative weights of rocket engines which are low compared to other types of propulsion units, the penalty involved in carrying the rocket boost system throughout the flight is not great. As a matter of fact, the lifting surfaces required to get the aircraft off the ground while heavily loaded with propellants are used advantageously for high altitude cruise and for landing at low speeds with turbojet propulsion alone. ✦



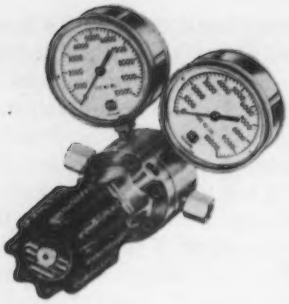
Rocket engine installation is shown in Mach 3 transport with mixed powerplant. Airframe design is generic.

• CONVAIR FORESEES WINDOWLESS TRANSPORT

Mach 3 commercial transports of the 1970's may be equipped with sightseeing television screens instead of windows for each passenger. Concept of windowless craft was advanced by R. C. Sebold, vice president-engineering at Convair.

Sebold said the craft might also feature seats pivoting like rocking chairs during steep takeoffs and landings. Sophisticated computers would provide flight information and monitor airplane performance.

Eliminating windows, said Sebold, would facilitate design of a stronger and lighter passenger cabin. Nor would windows be particularly necessary; for at 60,000 to 80,000 ft. the sun is piercingly brilliant and the sky is midnight black.



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Models in bronze or stainless steel
Pilot operated type
Max. inlet: 3600 to 7000 psig.
Outlet range: 10-150 to 400-7000 psig.
Flows to 250 scfm.
Low torque: 35 inch-lb. at 7000 psig.
Panel mounting
Bulletins R12 and R18.

BPR SERIES BACK PRESSURE REGULATORS

Models in bronze or stainless steel
Adjustable relief ranges: From 25-500 psig. to 2000-10,000 psig.
Panel mounting
Bulletin R19

LR SERIES LOADER REGULATORS

Models in bronze or stainless steel
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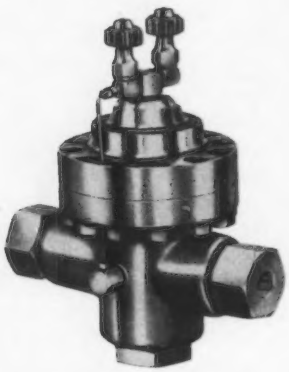
Outlet range: 5-200 to 200-10,000 psig.
Flow: 10 scfm.
Low torque: 35 inch-lb. at 7,000 psig.
60 inch-lb. at 10,000 psig.
Panel mounting
Bulletins R11 and R17



GD90, GD100A AND GD200A SERIES GAS-O-DOME REGULATORS

Models in bronze or stainless steel
Compensated, high-flow type
Max. inlet and outlet: 6000 psig.
Flows to 80,000 scfm.
Remote control and/or panel mounting provisions
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LV-10 LOADER VALVE

Made in bronze only.
Inlet and outlet: 7000 psig.
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Fast finger-tip control:
30° clockwise, loads;
30° counter-clockwise, bleeds.
Panel mounting
Bulletin LV-10

GD60 AND 80 SERIES GAS-O-DOME REGULATORS

Models in bronze
(stainless steel on request)
Inlet and outlet range: 2500 to 10,000 psig.
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Victor offers you choice of these and many other gas regulators for a wide variety of applications.

All come cleaned for oxygen service; LOX cleaned when specified. Operating temperature ranges: —67° F. to +250° F. (storage —80° F.) Modifications for special applications. Write now for Victor High Pressure Regulator bulletins and Regulator Inquiry Form 361A.

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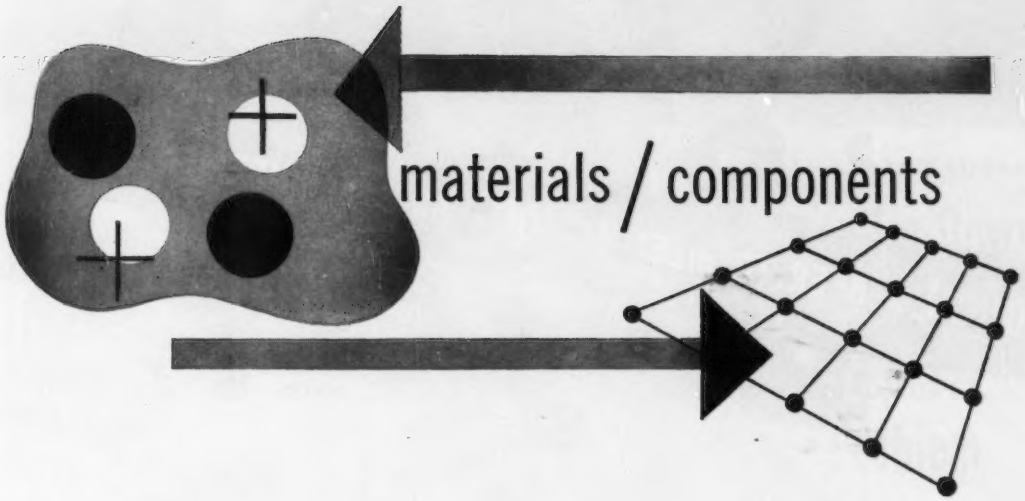


BONDING TEFLON

Fast method of bonding Teflon to itself and to other materials has been developed. Active sodium in solution reacts with the Teflon to form a carbonaceous film, which then serves as the anchoring medium. Most adhesives can be used on this surface.

The process lends itself to spot etching, batch treatment, and continuous-dip-lines for high speed production. Rates up to 60 fpm are possible on continuous lines if the Teflon product is preheated to 180 to

200°F before pulling it through the etchant.

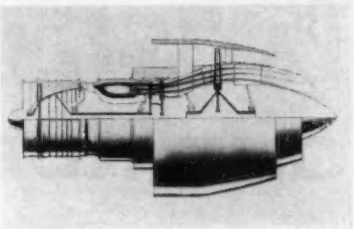
W. L. Gore & Assoc., Inc.

Circle 60 on postcard for more data

TURBOFAN VERSION OF J85 INTRODUCED

A 4000-lb-thrust powerplant, CF700-1, is turbofan version of G-E's J85 turbojet.

Fan version provides higher gross weight take-off capability, 20 per cent more range, and superior hot day performance. It has 0.69 SFC.



The CF700-1 weighs only 585 lb with a maximum diameter of 33 in. It is designed to operate most efficiently at speeds of Mach 0.5 to 0.9.

General Electric Co.

Circle 61 on postcard for more data

EVAPORATIVE COOLER

An evaporative cooling system to prevent airborne radar equipment from burning up in heat generated in hypersonic flight is being developed for the U. S. Navy.

Cooling unit employs ram air for preliminary cooling at subsonic speeds. It is effective for temperatures up to 120°F.

When inlet air reaches 120°F, a thermostat switches the system to evaporative cooling. This system uses a spray of water and a small amount of ram air to draw off the heat

This system is effective to Mach 2 and inlet temperatures of up to about 300°F.

For higher speeds and temperatures, heat is drawn from the unit by a thin spray of water which is boiled off.

Convair-San Diego

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FLEX-HOSE DEVELOPMENT

Multiple ply, corrugated metal hydraulic hose, known as RF-69, withstands temperatures of —450° to 1,200°F. It is designed to stand up under cyclic hydraulic shock loading, at peak impulse pressure of 4,500 psi. Lab samples have taken 100,000 cycles from 0 to 4,500 psi with pressure rise of 200,000 psi/sec.

Outer and inner plies of the hose are made of a stainless steel alloy.

Flexonics Corp.

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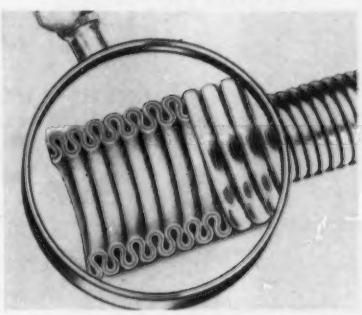

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NOW **tougher** THAN EVER . . . "SILICOL" has long been the engineers' choice for rubber parts to resist many difficult conditions of which temperature extremes, chemical attack and aging from weather and light are only typical. Because of its versatility, it is specified for all manner of applications from simple appliances to jet planes and guided missiles.

A **new** formulation of "SILICOL" now offers product designers greater versatility than ever. A few of its characteristics which can help you meet tough design requirements easier are: **TENSILE STRENGTH — 1600. ELONGATION—850%.**

The new "SILICOL" formulation is also even more important than ever to aircraft designers and manufacturers . . . In addition to the properties above, it meets AMS 3345 requirements for dry heat resistance, low temperature flexibility and oil resistance.

Whether you are designing new products, or improving existing ones, contact us for full details on "SILICOL" silicone rubber, and information on Colonial's custom rubber compounding and molding service. We can help you meet your "toughest" rubber parts requirements quickly, dependably and economically.

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As filter element collects contaminant, the differential pressure across the filter element rises. When this pressure reaches 80 ±10 psi, a red-tipped pin extends from the filter bowl to indicate that the element needs cleaning.

Bendix Aviation Corp.

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NEW PLASTIC FOR ATOM POWERPLANTS

Marlex, a rigid polyethylene, is highly suitable as a neutron shield and structural member.

Hydrogen content is claimed to be highest among all plastics. This property gives it the highest degree of neutron slowing or attentuation of any plastic. It is superior to water and concrete shielding.

Plastic Sales Div.
Phillips Chemical Co.

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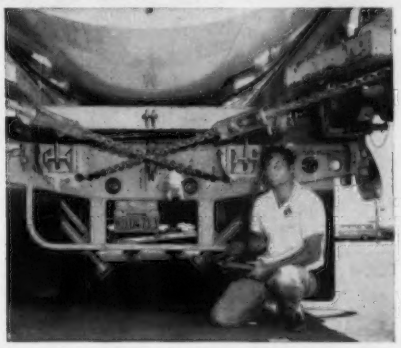
Heavy-duty tie-downs that operate easily were needed to secure Douglas THOR missiles to special transporting trailers. Aeroquip solved the problem by designing hydraulically tensioned chain tie-downs that are rated at 13 tons strength, yet weigh only 27 lbs. each.

These tie-downs are but one of the many types of web, cable and chain tie-down systems developed by Aeroquip's General Logistics Division, in rated strength from 150 lbs. to 60,000 lbs.

If you have a fabricating or transporting problem requiring any type tie-downs, let Aeroquip help you. Mail the coupon below for Bulletin 358.



This Aeroquip Chain Tie-Down is tensioned hydraulically to secure the missile to the trailer bed. It requires no wrenches to attach, provides a 3" take-up.

Aeroquip
REG. TRADEMARK

GENERAL LOGISTICS DIVISION
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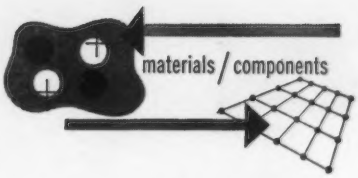

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It is driven by compressor bleed air. Pump incorporates its own simplified over-speed control which requires no linkages or electrical power supply. The unit can run without lubricant for extended periods.

Rated fuel flow is 10,000 lbs/hr to 48,000 ft. Maximum environmental temperature is 250°F. The unit weighs 8.1 lb.

Curtiss-Wright Corp.
Santa Barbara Div.

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It resists sunlight and ozone, remains flexible at —80°F and will operate at 375°F without degradation.

Minnesota Mining & Mfg. Co.

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Hydra-Power Corp.

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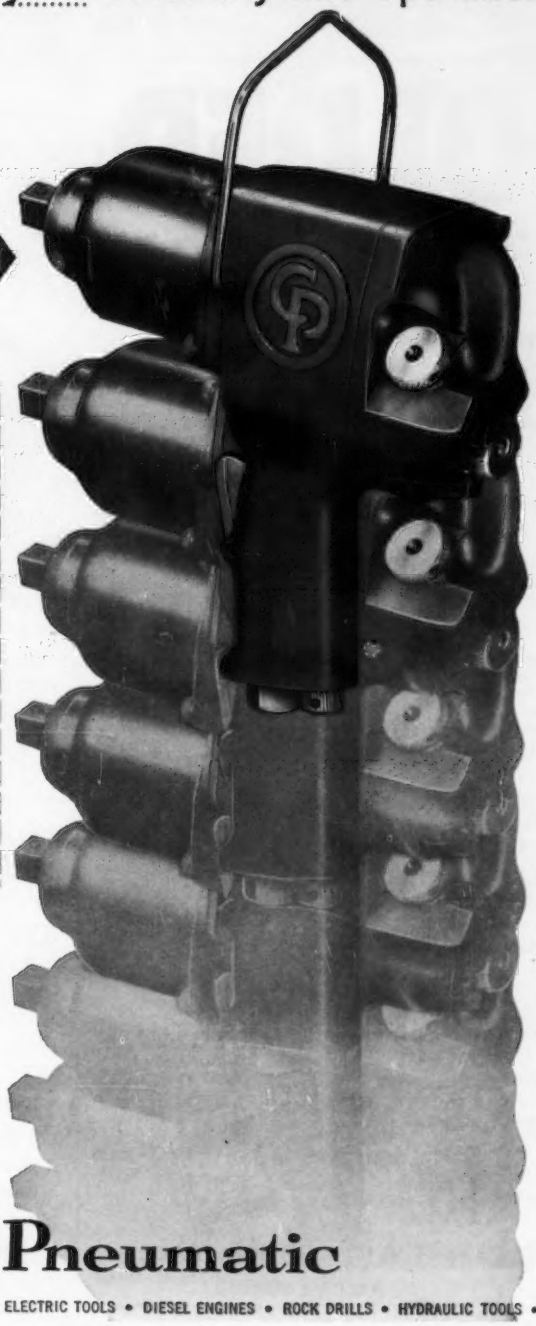

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* A complete line of Torque Control Screwdrivers and Nutrunners solve other threaded fastener torque problems. Available from No. 4 screw size to ⅜" bolt size.

More and more top-flight manufacturers are realizing that *proper bolt tightness* is a quality factor that gives them a sales edge over competitive products . . . their assembly line foremen know that the use of TORQUE CONTROL IMPACT WRENCHES in the driving of nuts and bolts to "correct torque" means:

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CP Torque Control Impact Wrenches give you the exact tightness you want in a fast, accurate, "one-shot" rundown that doesn't require a hand torquing follow-up to check work accuracy. Torque ranges from 15 to 600 foot pounds available.

Let a CP Fastener Specialist work with you on your problems. You'll be impressed by the easy handling qualities of these unusually compact tools. The torque control mechanism is totally enclosed and *all torque adjustments* are made quickly AND simply without special tools or fixtures. For further information, contact your nearest CP Office, or write: *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N. Y.*

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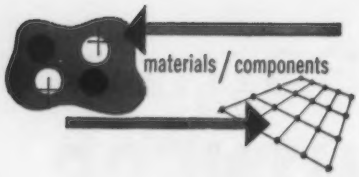

PAPER-BASE LAMINATE HAS COPPER CLADDING

A paper-base epoxy resin laminated plastic combines some of the performance of glass epoxy laminates with the fabrication ease of paper phenolic laminates.

It is lower in cost than glass base-epoxy laminates and is furnished in 37 x 49 in. sheets. Thickness ranges from 1/32 to ¼ in.

A copper-clad grade is expected to find wide use in computer applications where high reliability and reasonably low cost is desirable in the printed circuitry.

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SMALL 60-WATT APU USES SOLID FUEL

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Thompson Ramo-Wooldridge

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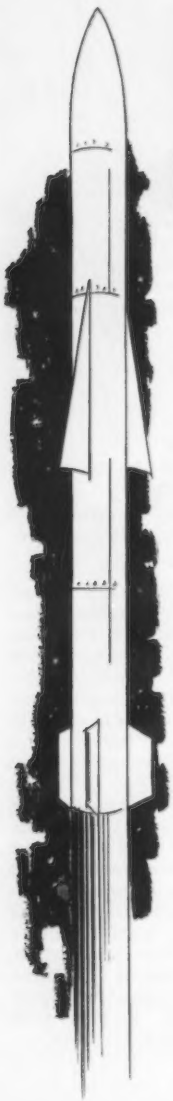

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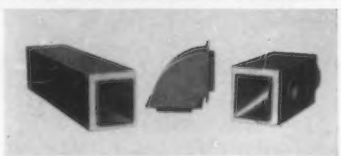

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FREE Descriptive Literature Available

STANDARD PLASTICS, INC.

FOGELSVILLE, PENNSYLVANIA

NEW *light-weight*

220,000 psi

ESNA SELF-LOCKING NUT*

for advanced
structural design...
high-tensile bolting

WEIGHT COMPARISON TABLE
in lbs. per 100 pieces

all drawings are shown in actual size

	½-28	⅝-24	¾-24	⅞-20	1-20
ESNA LH3393 (220,000 psi)	.44	.77	1.20	1.69	2.55
COMPETITIVE Lightest Nut (180,000 psi)	.60	1.00	1.50	2.15	2.82
COMPETITIVE Lightest Nut (220,000 psi)	.95	1.62	2.75	4.25	6.00

Tomorrow's hypersonic airframes must withstand flight stresses and related vibration conditions that would have seemed insurmountable even five years ago. Yet to achieve such speeds these aircraft will have to utilize lighter-weight structural components than their subsonic predecessors.

ESNA Type LH3393 double hex, external wrenching nut now offers the designer of tomorrow's airframes and missiles a structural fastener with the highest strength-to-weight ratio of any currently available self-locking nut.

Design refinements embodied in the LH3393 series consistently develop the full fatigue strength of 220,000 psi high strength bolts . . . yet these nuts are from 10% to 33% lighter, size for size, than even the lightest 180,000 psi locknut.

Additional weight savings are made possible by the smaller envelope dimensions of these new parts, since reduction of wrench clearance requirements permits reductions in the size of other structural components.

LH3393 series nuts are cold-formed from alloy steel, processed with the manufacturing skills and protected by the rigid quality control established during ESNA's 30 years of experience in supplying dependable aircraft quality fasteners. The same military approved, ELLIP-TITE locking device used on ESNA's complete line of NAS parts, assures reliable vibration proof self-locking performance at temperatures up to 550°F.

For specific dimensional, design and test data on ESNA's *new*, lightweight, 220,000 psi nut—Type LH3393, write to Dept. **S23-1298** Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

ELASTIC STOP NUT CORPORATION OF AMERICA

*U. S. Patent No. 2,588,372

Circle 21 on Inquiry Card

electronic products

POWER AMPLIFIER HAS FULL 20 WATT OUTPUT

Power Amplifier provides full 20 watts power output over its frequency range of 30 cps to 150 kc with 0.5 db attenuation.

Designated Model ATMS-2001, the amplifier is designed to deliver 20 watts of power from an input signal of 10 milliwatts. Input impedance is approximately 10k. Input circuit is provided with a step attenuator to control the amplitude of the input signal.

Technitrol Engineering Co.

Circle 72 on postcard for more data

SCANNING SPECTROMETER

Gamma spectrometer automatically scans pulse height spectrum from 100 per cent to 0 per cent without employing a motor drive system.

Low-level reset and upper-level discriminator control permits scanning. Unit then resets automatically and repeats the scan if desired.

Model SS-1 incorporates DD-2 non-overload linear amplifier, built to revised Oak Ridge specs. Window width of pulse height selector is adjustable from 0 to 10 volts.

The Victoreen Instrument Co.

Circle 73 on postcard for more data

SPACE AGE RADIOGRAPHY

High energy microwave linear accelerators are capable of generating intense x-ray outputs for radiographic inspection of space age materials and equipment.

Machines have been developed with electron energy ranges of 2 to 8 million electron volts and 3 to 15 million electron volts (Mev). One, the 8-Mev Model LR-8, is designed specifically for high-speed, precise radiographic inspection of thick sections of steel and of complex mechanical and electronic assemblies in the nuclear and missile industries. The other, the 15-Mev Model LR-15, is designed for high-speed precise radiographic examination of solid rocket propellants.

High Voltage Engineering Corp.

Circle 74 on postcard for more data

NEW CIRCUIT CONCEPTS IN DIGITAL COMPUTER

Model 1604 low-cost computer can be used for large volume process control and data logging, automatic test data reduction, air traffic control, missile control.

First production computer is being installed in the U. S. Navy Post-graduate school at Monterey, California.

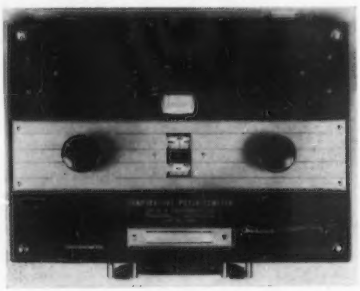
Computer is capable of utilizing standard input-output equipment manufactured by other companies. It is of modular construction.

Internal memory of the 1604 is a large-capacity magnetic core storage system providing high-speed, non-volatile, random-access storage for 32,768 48-bit words.

Control Data Corp.

Circle 75 on postcard for more data

POTENTIOMETERS CHANGE RANGE IN MINUTES



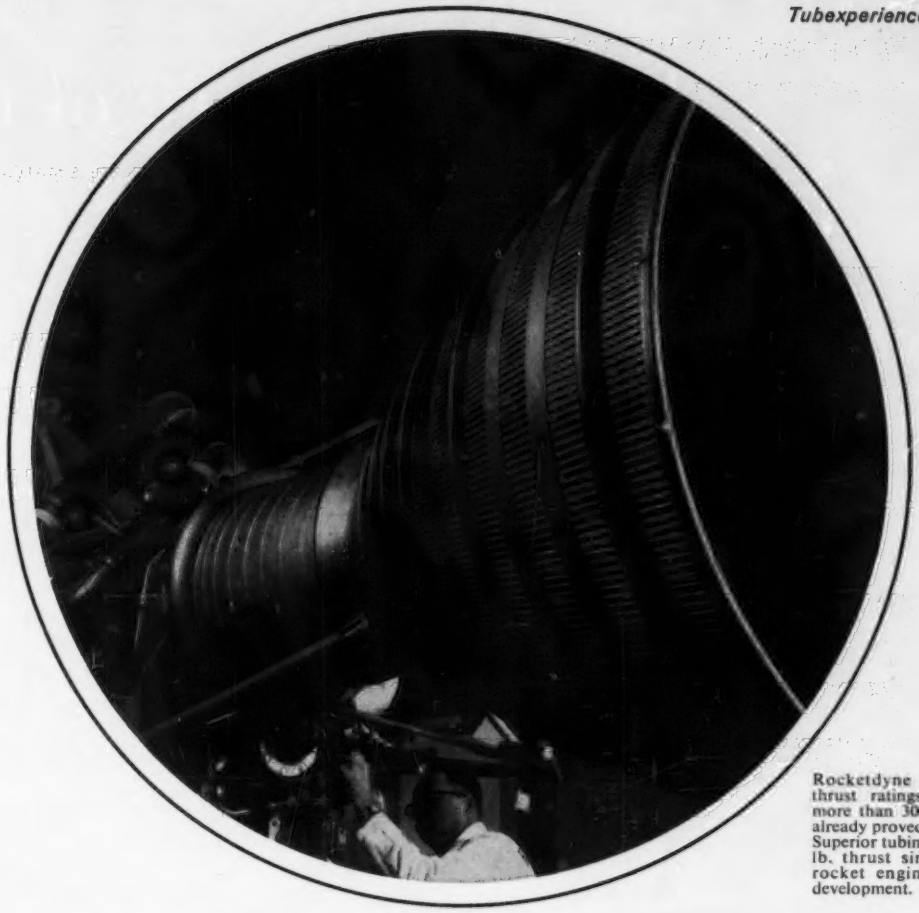
Single-range and double-range portable temperature potentiometers offer new design and are available in any of 20 interchangeable temperature ranges and four millivolt ranges.

Operator changes range with a screwdriver by inserting a new circuit panel, a 27½-inch scale and, if necessary, binding post studs.

Leeds & Northrup Co.

Circle 76 on postcard for more data

Tubexperience in action



Rocketdyne engines with thrust ratings of 5000 to more than 300,000 lb. have already proved the quality of Superior tubing. A 1,500,000 lb. thrust single chamber rocket engine is now in development.

Superior Thin-Wall Nickel Tubing Survives Rigors of Preparation for Outer Space

Thrust chambers of the Rocketdyne engines that propel the Atlas, Thor and Jupiter missiles into outer space are composed of over 200 pieces of formed and shaped Superior Grade "A" nickel tubing. Tubing must meet rigid design requirements and be amenable to exacting and intricate forming and fabrication. Finished parts are subjected to tests that must insure reliability. Typical of the unusually severe fabrication, test and operational conditions it must survive are the following.

- Die-press operations which develop pressure of 600 psi in the press and up to 20,000 psi in the tube while forming cross-section shapes varying from round to rectangular to octagonal.

- Brazing operations which subject the tube to as many as 15 heating and cooling cycles at approximately 1200°F.

- Test firings far in excess of required tactical maximum in which the only material between the coolant in the tubes and the combustion gases (at approximately 5000°F and high pressures) is the very thin wall of tubing.

Only the highest quality tubing, produced and fabricated with master skills, is good enough for the thrust chambers in which Superior tubing serves. That is why Rocketdyne Division, North American Aviation, Inc., depends on Superior for much of its tubing needs.

Superior's experience in the nuclear and missile tubing field is extensive. More than 120 analyses in a wide range of ID, OD and wall thicknesses are now available. They are described in Bulletin 41. Write for a copy today. Superior Tube Company, 2053 Germantown Ave., Norristown, Pa.

"A" Nickel is a registered trademark of International Nickel Co.

Superior Tube

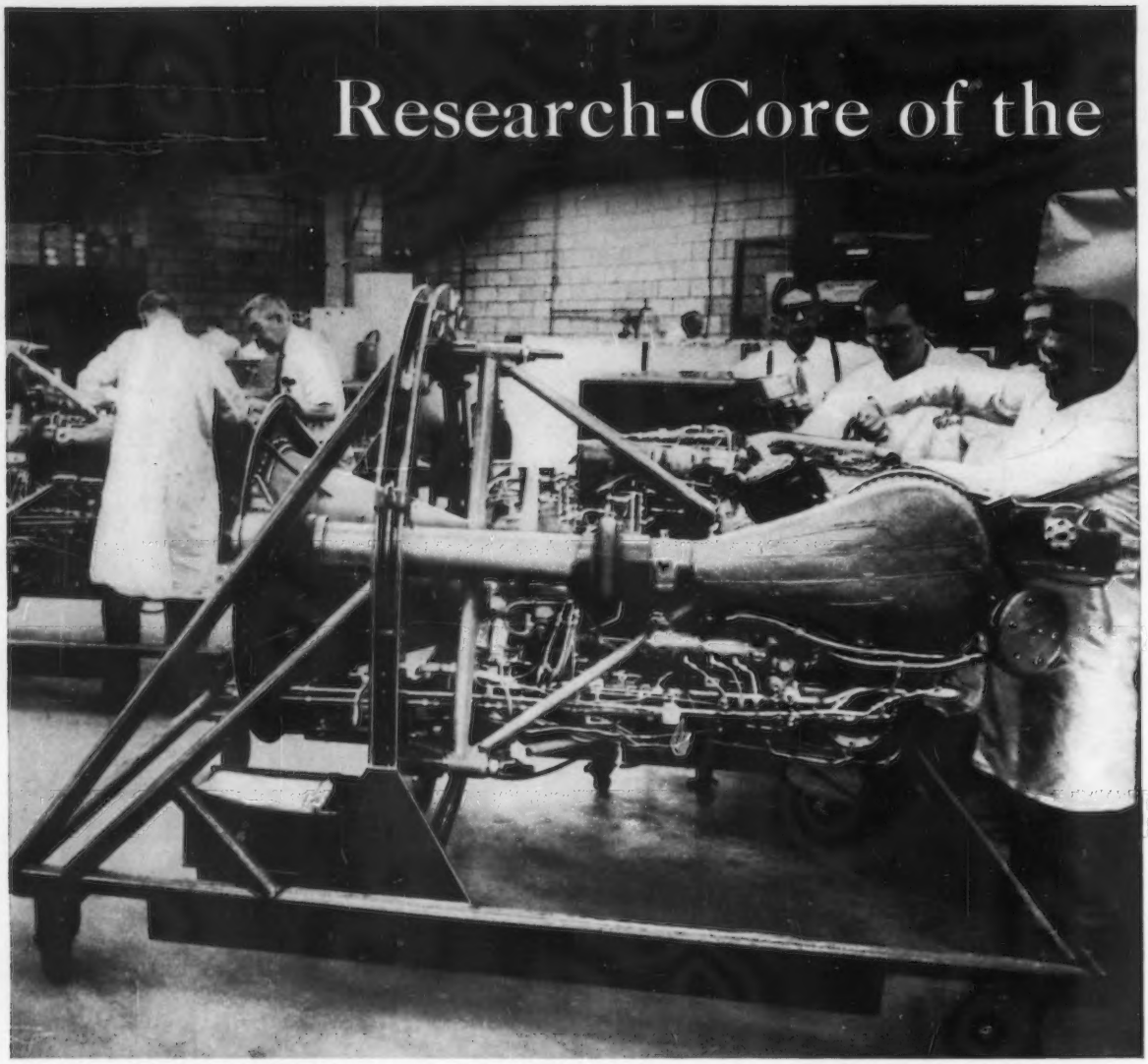
The big name in small tubing

NORRISTOWN, PA.

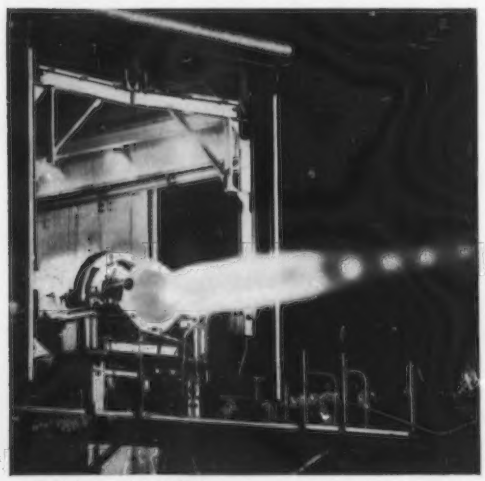
All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Research-Core of the



Most powerful single chamber liquid rocket engine ever built for manned flight—XLR-99—will drive the X-15



Test firing the XLR-99 . . . a major step in research supporting special design and production techniques.

North American Aviation Test Pilot, Scott Crossfield stands by the X-15—America's first manned space craft.

X-15

In designing and building the powerplant for the X-15, Reaction Motors Division of THIOKOL has tamed for human flight one of man's most awesome power sources, the large liquid rocket engine . . . has successfully met many of the greatest challenges ever put to rocket research.

Problem: develop an engine as powerful as an ICBM sustainer, make it controllable and pilot-safe.

This project without precedent demanded completely new concepts in chemistry and metallurgy, in laboratory testing, propellant handling, in use of exotic materials and fabricating techniques.

Basic and applied research in all these and other facets of rocket design and development have resulted in a throttlable powerplant conservatively rated at 50,000 lbs. of thrust (500,000 horsepower). An engine that will respond to pilot's wishes . . . fly him at speeds in excess of 4000 mph, better than 5 times the speed of sound . . . carry him to altitudes of 100 miles, the fringe of outer space . . . and above all bring him safely back to Mother Earth.

THIOKOL is now moving into new phases of rocket propulsion, opening up great career opportunities.

Engineers and scientists will find stimulating work in **astronautical systems analysis, thermodynamics, infra red, electronics of rocket exhaust, electromagnetics, solid state physics, high temperature gas dynamics, in many areas of fundamental and applied research.**

Opportunities also exist for chemists—in **propellant analysis, shock wave phenomena, combustion processes, fast reaction kinetics, high vacuum techniques.**

Inorganic Polymers, Propellant Formulation, Fluorine Synthesis, Metal Hydride Synthesis, Ion and Plasma Propulsion, Magnetohydrodynamics, Nucleonics . . . these are but a few of the additional areas in which accomplished and experienced people are needed.

The THIOKOL Chemical Corporation operates plants in Huntsville, Alabama; Moss Point, Mississippi; Brigham City, Utah; Bristol, Pennsylvania; Denville, New Jersey; Trenton, New Jersey; Elkton, Maryland; Marshall, Texas.

For full information, write Personnel Director at any plant address above.

Thiokol®

is Research to the Core

THIOKOL CHEMICAL CORPORATION
Bristol, Pennsylvania

®Registered trademark of the Thiokol Chemical Corp. for its rocket propellants, liquid polymers, plasticizers and other chemical products.

Circle 23 on Inquiry Card

electronic products

MACHINE AUTOMATES TRAINING PROCEDURES

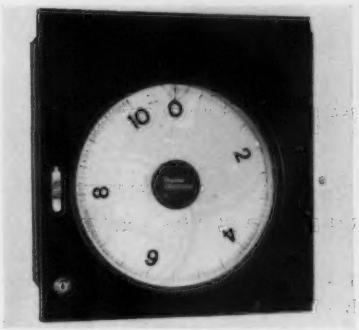
By treating the industrial trainee as an intelligent human being, "Tutor" teaching machine advances him at a rate determined by his demonstrated ability to absorb the word or picture information presented. It also records progress and provides a record of the individual's approach and reasoning progress.

The picture-projector automation system locates and presents any selected image or images when a number is punched on its keyboard. If punched number is incorrect, image tells the student, supplies additional data for another try.

U. S. Industries Inc.

Circle 77 on postcard for more data

INSTRUMENTS OBSERVE AND/OR CONTROL

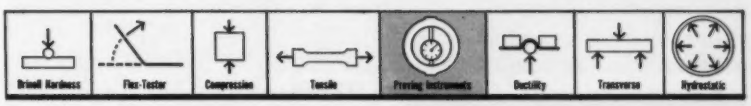


Self-balancing potentiometer and bridge type instruments indicate and control any variable that can be converted into an electrical quantity, such as dc potential, current or resistance.

Instruments feature a new high-gain servo-amplifier that provides exceptional sensitivity and stability.

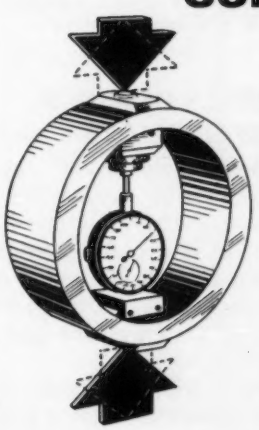
Thermo Electric Co.

Circle 78 on postcard for more data



proving rings to measure any load

COMPRESSION or TENSION



Steel City offers two styles of proving rings which require no adjustment during use. The dial-indicator ring (illustrated) measures deflection in increments of 0.0001". Applied load or force is determined from a calibration report furnished with each instrument*. With this type of ring, even an inexperienced operator can repeat readings as close as 1/10 of 1%.

Optical-type proving rings, developed for the USAF, use a ruled scale and a high-powered microscope for readings in increments of 0.00002". Repeat readings as close as 1/20 of 1% can be achieved.

Compression and tension models are available in either style, with capacities up to 200,000 lb., all manufactured of special-alloy steel by experienced craftsmen. They are used for calibrating Brinell testers, testing machines and presses, and load cells, or for measuring applied loads.

* *National Bureau of Standards calibration report when desired.*

Write for literature, prices and name of nearest distributor.

Steel City Testing Machines Inc.

8823 Lyndon Ave., Detroit 38, Mich.

Circle 24 on Inquiry Card

ATOMIC FUEL ON TV

The top of a radioactive fuel element is shown over a Spectra-closed-circuit television system as it is removed from the core of the Sodium Reactor Experiment (SRE), a nuclear power project conducted by Atomics International.

The closed circuit TV systems are built to customer's requirements in nuclear and other work.

Photo Research Corp.

Circle 79 on postcard for more data

COLOR FILM RECORDS STUDY DATA, FLIGHTS

Color motion picture films can track a speeding missile and pinpoint small changes in flame patterns.

The SO-260 film has normal exposure index of 160 (16 times as sensitive to light as Kodachrome Movie Film). In use for missile data recording, the film has been exposed at indexes up to 500. Film's tungsten-balanced (artificial light) companion, Eastman Color Reversal Film, Type B, SO-270, has a normal exposure index of 125.

Available in 16mm and 35mm sizes.

Eastman Kodak Co.

Circle 80 on postcard for more data

NEW DRILLS DESIGNED FOR SUPER ALLOYS

Heavy duty "3300" Jobbers Length drills are designed for drilling aircraft and missile super alloys and high strength steels. They work efficiently at high temperatures and are used with either stationary or portable drilling units.

Made from 8 per cent cobalt high speed steel with a high vanadium content, their short flutes give maximum rigidity. Special point design provides good penetration and thrust reduction.

National Twist Drill & Tool Co.

Circle 81 on postcard for more data

POCKET CALCULATOR TOTALS 99 TRILLION

Universal calculator has numerical capacity of a large machine calculator, yet is carried easily in the pocket. All parts are stainless steel or other rust and tropic proof metals.

Called the "Curta," calculator does problems in multiplication, addition, division, subtraction, squares, cubes, square root, percentages, formulae.

Model I totals up to 99 billion. Model II totals to 99 trillion.

8 oz. calculator is manufactured by Contina Ltd., Vaduz, Liechtenstein.

Isis Inc.

Circle 82 on postcard for more data

MICROSCOPE FOR SCRATCH INVESTIGATION

Recent attachments for Scratch Investigation Microscope permit its use for measuring scratches and pits on the external surface of extruded metals with diameters ranging from .125 in. to 3 in.

The Scratch Investigation Microscope can be used on flat or curved surfaces. Range of measurement is from .0005″ to .012″. Illumination of the surface is at an oblique angle, giving a magnification in depth of four times the lateral magnification. The instrument, portable, may be used with battery powered illumination.

Engis Equipment Co.

Circle 83 on postcard for more data

LOW-COST SOLAR FURNACE

Low-cost 60 in. diam. solar furnace is available in a "Do-It-Yourself" kit or assembled.

It includes automatic tracking system, remote-controlled sample positioner, and temperature adjustment and power supply.

Waltham Precision Instrument Co.

Circle 84 on postcard for more data

FIXTURE "MOLDS" GRIP

New holding fixture "molds" its grip to any shape, can be actuated hydraulically, pneumatically, or through solenoid valves. The fixture can now be synchronized with the operation of any machine tool in high speed production.

All models are built in four standard sizes. Maximum jaw openings range from 1 9/16 in. to 6⅛ in. Device can be used in automatic as well as manual operations.

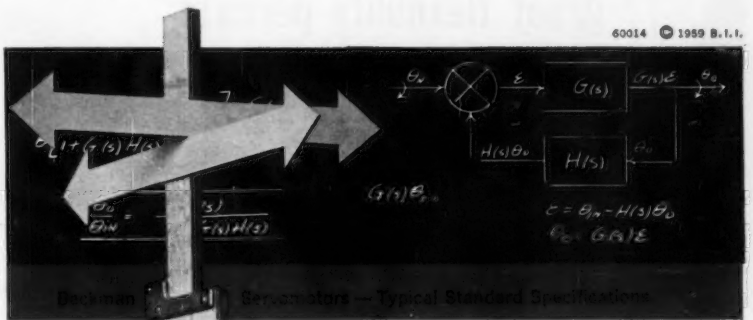
Die Supply Div.
E. W. Bliss Co.

Circle 85 on postcard for more data

sophisticated servo solutions

size 8's that do the work of 10's . . . 15's with 100,000 rad/sec² acceleration . . . 11's and 18's with inertia or adjustable velocity damping. Extract your solution from an infinitude of BECKMAN servomotors.

To satisfy the unknowns in your system, try these representative specs on your slipstick.



Beckman Servomotors — Typical Standard Specifications

	Size 8 servomotor-rate generator Model 8MG420/410	Size 11 velocity-damp servomotor Model 11VM460	Size 15 servomotor Model 15SM461	Size 18 inertia-damp servomotor Model 18IM460
Excitation	26v 400-cycle	115v 400-cycle	115v 400-cycle	115v 400-cycle
Length, inches	1.350	2.033	1.375	2.525
No-load, rpm	6,000	5,300	6,000	4,700
Torque at stall, oz. in.	0.22	0.63	1.45	2.35
Acceleration at stall, rad/sec²	68,000	22,200	100,000	22,200
Output voltage volts/1,000 rpm	0.1	—	—	—
Null voltage, millivolts	4	—	—	—
Additional damping available dyne cm. sec. / radian	—	10-100 (adjustable)	—	940

There are 10^{20} standard & spec types available in these popular sizes!

For complete crib-sheets . . . specs, drawings, torque speed curves and unit characteristics . . . write for data file F 123.

Beckman® / Helipot®

Helipot Division of Beckman Instruments, Inc.
Fullerton, California
Engineering representatives in 29 cities

potentiometers: dials: delay lines: expanded scale meters: servomotors: breadboard parts

MetalFilm Strain Gages . . .

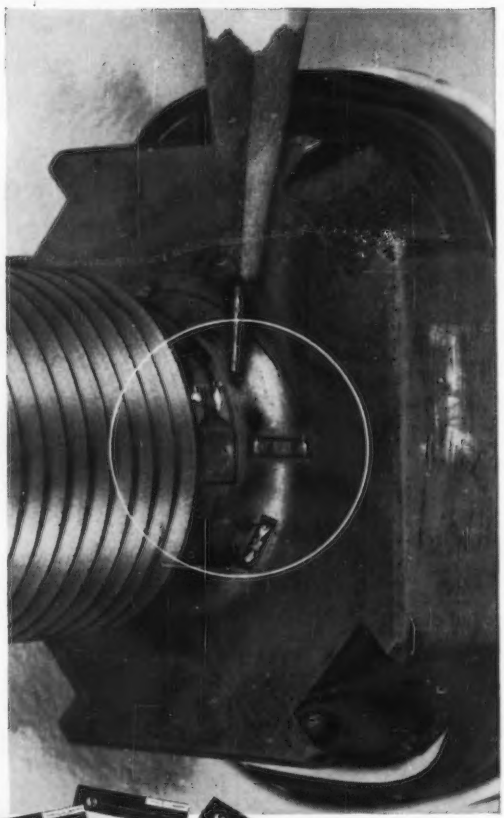
great flexibility permits high conformability

Bonded resistance strain gages, improved at Tatnall by using ultra-thin, precisely controlled alloy foil with plastic, strippable backings, can conform to tight-radius, convex or concave curves and other difficult shapes.

MetalFilm Strain Gages are temperature compensated and stabilized to give very precise readouts in high and low temperature ranges.

Many can be applied in less than 5 minutes.

Every MetalFilm Strain Gage is backed by direct factory technical service. Discounts are given for quantity purchases.



Contact our Department AM-12 for literature and information on specifications, application and prices.

TATNALL MEASURING SYSTEMS COMPANY

A SUBSIDIARY OF THE BUDD COMPANY • P. O. BOX 245 • PHOENIXVILLE, PENNSYLVANIA

IN CANADA—TATNALL MEASURING AND NUCLEAR SYSTEMS, LTD. • 46 HOLLINGER RD. • TORONTO 16, ONT.

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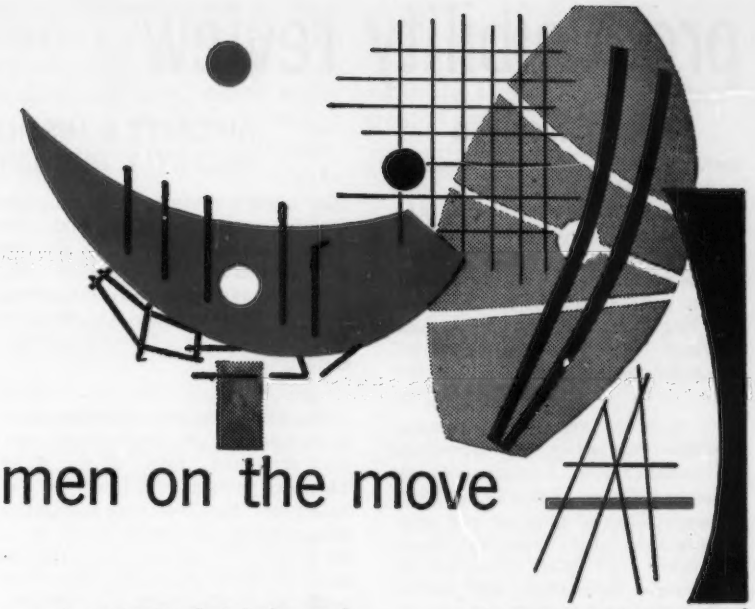
Iden F. Richardson
Hughes Aircraft

Louis P. Clark
Radiation Inc.

Jack Baxby
McCormick Selph Associates

Jay W. Thornhill
Texas Instruments

Edward C. Carman
Avco



men on the move

R. C. FULLER, elected vice president and group executive of Bendix Aviation Corp. DR. GEORGE K. HESS JR., recent test manager for the "Kiwi-A" nuclear rocket engine control project, appointed staff assistant in charge of advanced planning, Research Laboratories division. BRIAN A. WILSON, appointed sales engineer for the Filter Div. WILLIAM O. ROBINSON, named senior sales engineer, Rocket Inert Parts, Bendix Products Division. STEPHEN P. SANDERS, promoted to chief of environmental testing laboratory, Bendix Products Div.-missiles.

DR. JOHN L. ZAMBROW, appointed director of engineering for Sylvania-Corning Nuclear Corp.

IDEN F. RICHARDSON, appointed manager of Hughes Products Group, commercial division of Hughes Aircraft Co.

LOUIS P. CLARK, appointed manager of the Florida Div., Radiation Inc.

JACK BAXBY, appointed project manager, r&d contracts, McCormick Selph Associates.

JAY W. THORNHILL has transferred from the Central Research and Engineering staff of Texas Instruments Inc. in Dallas to head the firm's new Nuclear Development Department, Attleboro, Mass.

EDWARD C. CARMAN, appointed director of business development planning for Avco's Nashville Div.

RICHARD G. BOWMAN, appointed technical assistant to the president, and CARVER T. BUSSEY, special assistant to the president, at Republic Aviation. DR. SAMUEL LUBKIN, appointed staff consultant to the Missile Systems Division.

WILLIAM P. MONTAGUE, named assistant director of electronic requirements for the Martin Co. ARTHUR R. CHRISTIE named manager of Martin's Washington office. DR. HUGH L. COX, appointed lead engineer on advanced classified projects, Martin-Denver.

P. R. GEHMAN, appointed manager-missile applications engineering in the Air Force Requirements Operation of General Electric's Missile & Space Vehicle Dept.

AIKMAN ARMSTRONG, appointed chief application engineer for nuclear products, Marketing div., Power Systems Group, Marquardt Corp.

DR. LLOYD P. SMITH has joined Aeronutronic, division of Ford Motor Co., as director of Research Operations.

HANS W. WEICKARDT, named section chief of stress analysis in the research and development engineering division, Solar Aircraft Co.

JOHN P. SCHAFER, named vice president of Hexcel Products Inc.

NORVIN E. ERICKSON, appointed base manager for Aerojet General's operations at the Air Force Missile Test Center, Cape Canaveral, Fla. RICHARD W. POWELL, appointed manager of Aerojet's Avionic's Div.

producibility review

BOOKS RECEIVED

ROCKET ENCYCLOPEDIA ILLUSTRATED. J. W. Herrick and E. Burgess. *Aero Publishers*, 1959. 607 pp. $12.50. Compilation of rocket terminology, theories, and facts; includes photographs and pictorial diagrams. Terms defined, amplified. Historical and biographic data have also been provided. The foreword is by Dr. Theodore von Karman.

DATA BOOK ON PHYSICAL AND ENGINEERING PROPERTIES OF MATERIALS FOR NUCLEAR FUEL ELEMENTS, H. H. Hausner. *Sylcor*, 1959. 55 pp. $1.00. A compendium of physical and engineering data about elements, alloys, compounds and other materials in the design, fabrication and use of nuclear fuel and control elements. It is intended to supply information not yet widely available in conventional reference sources. Eighty tables are presented: the first contains thermal-neutron cross sections of 50 commonly available elements; succeeding ones give various physical and thermal properties of uranium (18 tables), uranium alloys (11), thorium (6), plutonium (5), ceramics (10), zirconium and zircaloy-2 (10), aluminum (5), stainless steel (4), graphite (5) and other high-temperature materials (5).

PROBLEMS IN TECHNICAL PUBLICATION MANAGEMENT (A Preliminary Survey) *R. Ward*. 1959. 22 pp. $3.50. This pamphlet is published as Volume I of "The Technical Publication Management Handbook." It is a brief study of management problems encountered in preparing instruction books and other technical information for industry, the consumer, and the Armed Forces.

AVIATION FACT AND FIGURES. *American Aviation Publications*. 1959. 147 pp. $2.00. A compilation of significant statistical data from the early years of aviation to the present. Subjects covered include: production and facilities, space programs, R & D, manpower, finance, airlines and transportation, aviation export, public relations officials of Aerospace Industries Assn. member companies, etc.

AIRCRAFT & MISSILES DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

GOVERNMENT RELEASES

TWENTY-SEVEN ATOMIC ENERGY COMMISSION REPORTS. These are related to research on reactors, particle accelerators, and high-voltage machines. Report list, (OTS 59-329), released Oct. 13, 1959. Obtainable through the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

TWENTY-TWO ATOMIC ENERGY COMMISSION REPORTS. Report list (OTS 59-290), released on Sept. 24, 1959.

worth asking for

TECHNICAL LITERATURE LISTED HERE IS AVAILABLE WITHOUT CHARGE FROM THE VARIOUS MANUFACTURERS.

Radiation Sources

Brochure details capabilities to provide radiation sources for irradiation research, radiography, teletherapy.

Nuclear Systems Div.
The Budd Co.

Circle 86 on postcard for more data

Assignment: The Future

Complete function breakdown of research labs employing some 1,400 people. Describes achievements, studies, in crystallography, engines, metals; also basic research.

General Motors
Research Laboratories

Circle 87 on postcard for more data

Triga

Outline of Triga Mark II training—research reactor.

General Atomic

Circle 88 on postcard for more data

Nuclear Studies

Booklet describes uses of nuclear power in industry. Includes outline of advanced home-study program in Nuclear Engineering Technology.

Crei Atomics

Circle 89 on postcard for more data

Isotopes For Industry

Booklet, "Industrial Radiography With Radioisotopes."

Picker X-Ray Corp.

Circle 90 on postcard for more data

Re-entry Projects

Two new booklets describe re-entry and recovery project in the Thor-Able and Atlas missile programs.

General Electric Co.

Circle 91 on postcard for more data

Nuclear Instrumentation

Illustrated bulletin on line of nuclear instruments and monitoring systems.

The Victoreen Instrument Co.

Circle 92 on postcard for more data

Noise

Bibliography on combustion-driven oscillations.

Battelle Memorial Institute

Circle 93 on postcard for more data

Levinthal Facilities

Professional background on engineers concerned with high-power equipment; nuclear division described.

Levinthal Electronic Products

Circle 94 on postcard for more data

Mag-Thorium Alloys

Article reprint.

Dow Metal Products Co.

Circle 95 on postcard for more data

Data Processing

Line of Data Processing Equipment.

Leeds & Northrup Co.

Circle 96 on postcard for more data

Re-entry Ablation

Collection of scientific papers on the behavior of reinforced plastics at very high re-entry temperatures. Papers are by scientists at the G.E. Aerosciences Laboratory.

Missile & Space Vehicle Dept.
General Electric Co.

Circle 97 on postcard for more data

Ultrasonic Cleaning

Bulletin 16-A, "How To Get The Most Out of Ultrasonic Cleaning."

Oakite Products Inc.

Circle 98 on postcard for more data

Grommets

Sample card holds three WSI one-piece, solid nylon flip grommets.

Western Sky Industries

Circle 99 on postcard for more data

Beat the Heat Barrier With Handy & Harman High Temperature Brazing Alloys!

Some of the problems of elevated temperature joint strength and oxidation resistance in heat-resistant alloys are being solved today by a relatively new group of Handy & Harman high temperature brazing alloys. These alloys embody certain unique characteristics, all of which are requisite for high temperature brazing:

- They have good strength and oxidation resistance at recommended temperatures.
- They are ductile, with the ability to withstand vibration and stress at elevated temperatures.
- These Handy & Harman alloys provide minimum solution and penetration of the metals being joined; this is a particular advantage when joining thin sections.
- These alloys effectively join stainless steels, low alloy steels, nickel-base alloys, cobalt-base alloys and other high temperature metals including refractory types.

The list of successful applications includes jet engine parts, heat exchangers, rocket motors, clad metals, honeycomb structures, turbine blades and many others. The following are brief descriptions of these Handy & Harman alloys:

LITHOBRAZE 925 For short time operation to 900° F, continuous at 500° F. Very ductile, virtually no solution of base metal. Good salt-spray corrosion resistance.

HI-TEMP 30 For continuous service 900° F-1000° F. Fairly ductile, moderate general solution of base metal.

PREMABRAZE 128 Continuous service up to 1500° F. Ductile, moderate solution of the base metal. Tensile strength at 1600° F in 304 stainless steel is 20,000 psi (short time test).

PREMABRAZE 130 Same properties as PREMABRAZE 128, but freer flowing and lower brazing temperature.

PREMABRAZE 101 Continuous operation in 1800° F-2000° F range (based upon limited oxidation tests). Ductile, moderate solution and penetration of the base metal.

Alloy	Nominal Composition	mp° F	fp° F
LITHOBRAZE 925	92.5 Ag 7.3 Cu .2 Li	1435	1635
HI-TEMP 30	70 Mn 30 Ni	1885	1920
PREMABRAZE 128	72 Au 22 Ni 6 Cr	1785	1900
PREMABRAZE 130	82 Au 18 Ni	1740	1740
PREMABRAZE 101	54 Pd 36 Ni 10 Cr	2250	2300

Data sheets and complete details on each of the above Handy & Harman alloys are available upon request to Handy & Harman, 82 Fulton Street, New York 38, N. Y.

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Circle 27 on Inquiry Card

industry notes

Curtiss-Wright aerial platform (VZ-7AP) prototype is being tested at Edwards AFB for the Army.

Gyro-test room, Ferranti Ltd., Edinburgh.

Mockup of firm's nuclear power station at Lockheed's Georgia Div.

INDUSTRY ATTENTION ON NUCLEAR WORK

Nuclear activity is assuming increasing importance among firms in aircraft and missile activity. Here's the broad picture of current projects.

General Atomic, div. of General Dynamics, is studying feasibility of using controlled nuclear pulses for space vehicle propulsion. Program, known as "Project Orion," was begun July, 1958, and recently extended a year by $1-million Defense Department contract. GA developed the TRIGA family of reactors for training, research and isotope production.

Rocketdyne, div. of North American Aviation, has just established Nucleonics, a new engineering subdivision at Canoga, Calif. Purpose is to concentrate nuclear, ion, and related activities into one unit. Activities will include nuclear rocket engine design and analysis, nuclear rocket feed systems, and special studies.

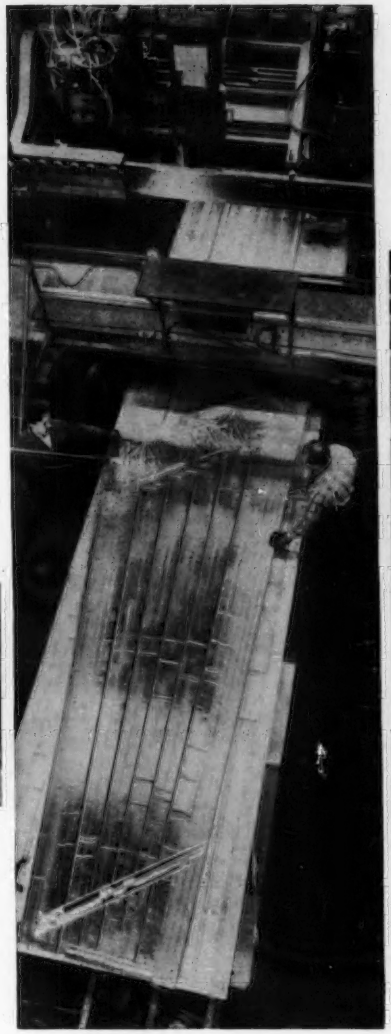
Atomics International, div. of North American Aviation, designs, develops, and builds a wide range of nuclear reactors. Has plant in Canoga Park, 290 acre field lab in nearby Santa Susana mountains. Has worked on "Pluto" nuclear ramjet project. Developed SNAP II (System for Nuclear Auxiliary Power).

Convair-Fort Worth won competition this March to work with General Electric on initial design of a nuclear-powered bomber prototype.

General Electric has been working on direct-cycle powerplant for nuclear plane since 1951. Over $200-million has been spent on development of available materials for direct cycle propulsion in ANP program. AEC and the Air Force, financing A-plane work, recently sliced direct cycle development funds by 15 per cent.

Pratt & Whitney, div. of United Aircraft, has been in ANP since development of indirect cycle propulsion system got up steam in 1954. Highly classified research is at CANEL (Connecticut Aircraft Nuclear Engine Laboratory), Middletown. Joint Committee on Atomic Energy recently said advances in the indirect cycle system appear "most promising." Firm's Florida Research and Development Center is developing liquid hydrogen, which has nuclear rocket applications.

Lockheed Aircraft was recently selected by NASA to



THEY CREATE THE IMPOSSIBLE—WITH ALCOA ALUMINUM

Not long ago, many of the components routinely turned out by the Franklin Balmar Corporation, of Baltimore, *would* have been quite impossible to fabricate—at *any* price.

They specialize in components of extreme intricacy—machined to precise tolerances. The components of the new Boeing B-52 wing, machined by Balmar as subcontractor for Fairchild Aircraft, are typical of the highly demanding work turned out by these precision "sculptors in aluminum."

Severe sculpturing can be performed satisfactorily only on aluminum of the highest quality. For this reason, Franklin Balmar must have top quality and dependable uniformity in the aluminum it uses. Alcoa has been able in all cases to satisfy these unusual requirements. This is why Alcoa® Aluminum is Franklin Balmar's first choice.

For Alcoa Aluminum alloys are predictably uniform. Alcoa 7178 alloy, for instance, in the wing panels of the B-52 fuel tank. Or any *other* Alcoa alloy. You can trust it to behave exactly the same, time after time. Once you've developed a production routine, you know it will produce identically reliable results continuously.

Another reason for Balmar's preference for Alcoa Aluminum is its high internal quality—an important consideration in work where the cost of machining may be many times the cost of the raw metal itself. A hidden flaw might ruin a piece *after* hundreds of dollars' worth of machining operations have been completed!

Preference for Alcoa Aluminum by Franklin Balmar Corporation is something—we hope—that should justify a similar preference on *your* part, when the need next arises. Contact our sales offices or write us for information: Aluminum Company of America, 2032-M Alcoa Building, Pittsburgh 19, Pa.

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

ALCOA ALUMINUM

Your Guide to the Best in Aluminum Value

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Good insulating properties make R/M Pyrotex an excellent material for rocket throats, aft insulators, and grain seat rings. Pyrotex can be molded or laminated into a wide variety of shapes.

Looking for a material that will withstand the elevated temperatures generated by missiles and rockets—internally from burning propellants, externally from aerodynamic heating? Must this material have good insulation and thermal properties, chemical and water resistance, and take a smooth finish? If so, one of R/M's family of Pyrotex reinforced plastics may be the solution to your problem.

The many outstanding thermal and structural features of R/M Pyrotex have led to its use on almost every U.S. missile. It has been fabricated into parts such as nose cones, fins, igniter tubes, rocket throats and sliver traps. Its exceptionally good dimensional stability makes possible mass production to precision standards. And it is low in cost. Write for additional information.

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REINFORCED PLASTICS DEPARTMENT, Manheim, Pa.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; Paramount, Calif.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

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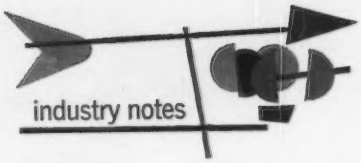


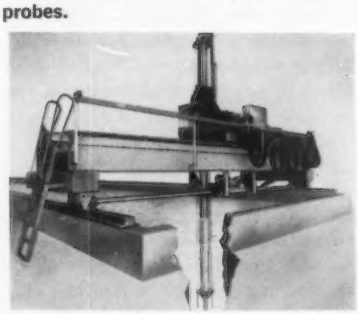
provide basic engineering data on continuing feasibility investigation of a nuclear rocket system.

Lockheed says that establishment of Godiva II, a pulsed reactor, at its Dawsonville, Ga., nuclear lab, now permits work in radiation effects and shielding where rate effects predominate. Lockheed has designed a portable atomic reactor suitable for air transportation to polar regions.

Other nuclear work at Lockheed: a special meteorology unit is studying weather variables affecting work with reactors. AN-ARRC-34, a complex communication system for an airplane, was irradiated until certain components failed. Similar irradiation test will soon be made with yaw damper of an F-104.

Martin is doing engineering studies on nuclear anti-submarine seaplane for the Navy. Firm developed SNAP III power generators and several types of portable ground reactors. In addition to above, Nuclear Div. is conducting materials studies, and just received an $838,163 AEC contract for development of "liquid fluidized bed reactor" which could eliminate need for control rods.

Instrument bridge was designed and built by Mechanical Div., General Mills, for positioning submerged radiation probes.



Aeronautics Div., **Chance Vought Aircraft,** is studying a nuclear-powered, low altitude ICBM, "SLAM." It would be powered by a nuclear ramjet engine.

Marquardt Corp. is studying feasibility of applying heat from nuclear reactors to ramjet engines. Designated "PLUTO," project is combined effort of AEC's Lawrence Radiation Lab, Atomics International, and Marquardt.

Goodyear Aircraft has proposed a nuclear-powered airship, to be operational by 1963. It could use a new rubberized dacron fabric, capable of withstanding radiation exposures up to one hundred million roentgens, developed by Aviation Products Div. of The Goodyear Tire and Rubber Co.

Bell Helicopter has completed feasibility studies of a giant nuclear powered helicopter.

Aerojet - General Nucleonics supplies research and training reactors. It is carrying out the gas-cooled reactor experiment for AEC at the National Reactor Test Station, Arco, Idaho and studying reactor systems for space power. Its studies are aiding development of nuclear rocket propulsion system.

Among other current work: **Douglas Aircraft,** studies for ANP; **Solar Aircraft,** design study of advanced weapon systems power unit; **Bendix Systems Div.,** communication, navigation, identification subsystem for weapon system 125A; **Boeing Airplane,** effects of nuclear radiation on electronic components and on seals. **Admiral Corp.'s** studies on electrical and electronic equipment are contained in ASTIA Doc. No. 155789 & 155790. A host of other firms and institutions are going nuclear to varying extents.

What can you do with a remarkable instrument like this?

We knew we had an outstanding instrument in our product line when this readout device was introduced several years ago. It proved to be ahead of its time during those early days, but now this remarkable precision instrument for displaying data is gaining acceptance in many industries. It's about as big as a candy bar, and it will display, store, or transfer up to 64 different numbers, letters, or symbols without using complicated conversion equipment and "black boxes."

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We developed the Readall instrument for data display in flight control equipment. We knew the Readall instrument was fine but didn't know just *how* valuable it was. But one of our engineers did. He designed a complete new pipeline control system based on the new instrument. The application was a breakthrough in data handling, and the control system is a big success.

Naturally, we put the Readall instrument on the market so systems engineers could use it to improve their control systems. We announced the Readall instrument as ". . . an electro-mechanical, D.C. operated, readout device for displaying characters in accordance with a pre-determined binary code . . . a compact, self-contained device . . . which can be applied to the output of digital computers, teletype receiving equipment, telemetering systems, or wherever data must be displayed."

Other systems have been developed with separate units for data display, decoding, storing, and electrical readout. These separate units cost more and occupy more room. Market response confirms the need for *one, small,* inexpensive unit that does all three jobs. The Readall instrument serves the purpose.

We'd like to discuss possible applications for the Readall instrument with you. If you want information as to possible applications you have in mind for this remarkable instrument, please fill in the coupon.

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A topper in any language

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When you want extremely high reliability in printed circuits, with the additional advantages of flame retardance, chemical resistance, good solderability and high bond strength—specify Taylor XY-1 copper-clad laminate. It is self-extinguishing in 1 second, has excellent resistance to alkalis, acids and solvents, has a solder time resistance at 500°F. of 30 seconds in 1-oz. copper and 50 seconds in 2-oz., and a bond strength of 10 lb. in 1-oz. copper and 13 lb. in 2-oz. Sheets available with copper on one or both sides.

Unclad Taylor XY-1 has many advantages, too. It can be substituted for glass-base epoxy laminates to reduce cost and weight. It has excellent electrical, mechanical and machining properties. Contact us for complete technical data and expert guidance in applying this new material. TAYLOR FIBRE CO., Norristown 50, Pa.

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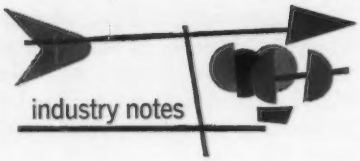


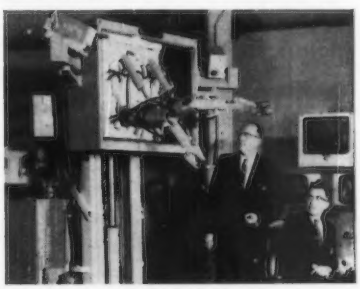
CONTRACTS . . .

The Army awarded Martin-Orlando $24-million for technical activities in Pershing system development. Aerojet-General received an $8-million subcontract from Grumman Aircraft to develop a high performance rocket powerplant for the Eagle.

Navy contracts included $58.8 million to Douglas Aircraft for futher A4D-2N Skyhawk production; $30,600,000 to Martin-Baltimore to modernize 57 more P5M-2 ASW Marlin seaplanes; $27,300,000 to Pratt & Whitney for advanced J-57 engines for the F8U-2N. The Navy awarded Chance Vought $10-million for additional F8U-2N fighters, $9,500,000 for modernizing F8U-1 Crusaders.

In R & D, $838,163 was awarded Martin's Nuclear Div. for developing a simplified, highly advanced reactor system. Pratt & Whitney Div., United Aircraft, received $100,000 in NASA funds to investigate heat transfer potentialities of a number of materials in a near vacuum. Tests would be conducted under the high temperatures that would be encountered in a nuclear-electric generating system.

"Mobot Mark I" developed by Hughes Aircraft is being used by Sandia Corp. on work for AEC.



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Through 70 years of war and peace, St. Louis Car has developed, tested and built transport and handling equipment . . . railroad stock . . . amphibious vehicles . . . aircraft . . . special-purpose carriers and mounts.

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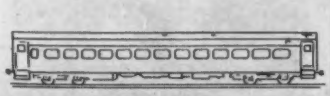
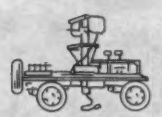

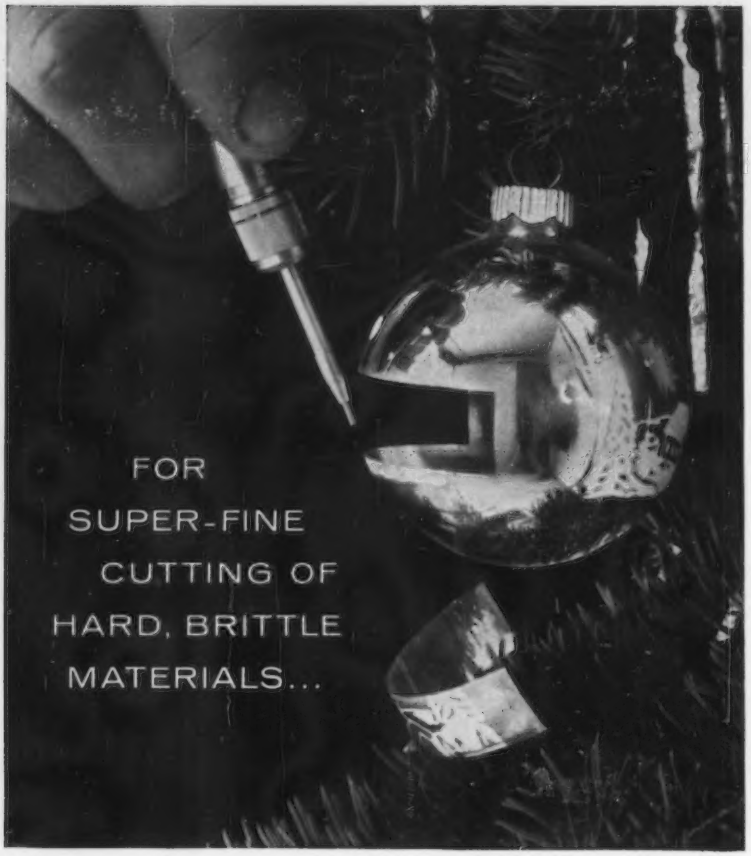

THE S. S. White Industrial Airbrasive® Unit

It may seem a Scrooge-like trick to slice up this Christmas decoration, but we think you will agree that it is a good demonstration of the ability of the Industrial Airbrasive Unit to cut fragile, brittle materials.

This unique tool is doing jobs that were up to now thought impossible. A precise jet of abrasive particles, gas-propelled through a small, easy-to-use nozzle, cuts or abrades a wide variety of materials such as germanium, fragile crystals, glass, oxides, ceramics, and many others.

Use it to make cuts as fine as .008"... or remove surface coatings without affecting base material... wire-strip potentiometers... deburr precision parts... adjust printed circuits... in the laboratory or on an automated production line.

Important too: *the cost is low*... for under $1,000 you can set up your own Airbrasive cutting unit!

Send us your most difficult samples and we will test them for you.

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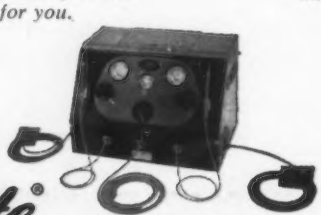

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industry notes

DYNA SOAR ASTRONAUTS & CONTRACTORS PICKED

Selection of Boeing and Martin as chief contractors for the Dyna Soar boost glider comes with "Dyna Soar Astronaut" program well underway.

Astronaut choices had been narrowed down to about 15 two months ago. These were being tested at Wright Air Development Center. WADC is systems manager under new management procedures aimed at integrating aeronautical knowledge, missile development, and data from X-15 and Mercury research.

The Air Force said Boeing will be responsible for manufacturing the vehicle portion of the system. Under the new management concept, Boeing will work closely with WADC in carrying out additional responsibility for integration of vehicle sub-systems, integration of vehicle and booster, and booster and test.

Martin will manufacture the booster, reportedly a Titan variety. Martin did not imme-

Two Hexcel aluminum honeycomb fins now on X-15 ejection seat prevent uncontrolled tumbling.

diately reveal if it is doing the work at Baltimore or Denver.

Each contractor will select all major sub-systems and components on a competitive basis regardless of working relations during the earlier development phase, Air Force added.

First step in present development program is design and test of a glider to bring a man back to normal landing from hypersonic flight speeds. Unmanned, and later, manned, gliders will be launched from Cape Canaveral down the Atlantic Missile Range to explore problems at speeds approaching orbital.

Dyna Soar has been funded for $53-million through Fiscal Year 1960.

Regarded essentially as a military research craft, vehicle is dynamically boosted with a rocket. Then it "soars" with wings to get aerodynamic lift. It is a joint program between the Air Force and NASA. Air Force Ballistic Missile Div. will be principal agency for adaptation of boosters in the program.

Martin team has been Bell Aircraft Corp., American Machine and Foundry Co., Bendix Aviation Corp., Goodyear Aircraft Corp., Minneapolis-Honeywell Regulator Co.

Boeing team: Aerojet-General Corp., Chance-Vought Aircraft, Missile Div., North American Aviation, Ramo-Wooldridge Co., General Electric Co., Autonetics Div., North American Aviation.

STEEL SHORTAGES

T. Keith Glennan, NASA head, estimated that "Vega" development has been set back at least three months because of shortages caused by the steel strike.

Vega is tagged to be ready in early 1960 to thrust 4,000 lb payload into orbit.

Well established in special nuclear applications, BERYLLIUM METAL is now being used and tested for structural components in other industries.

High strength to weight ratio • good high temperature properties • high modulus • excellent heat sink characteristics make this light metal attractive for current and future design.

Availability has improved—in quantity and mill forms—fabrication sources are increasing rapidly.

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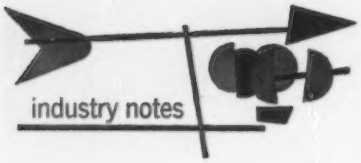

AEROSPACE LOG

Nov. 4—One ton Mercury capsule, fired to seven miles from Wallops Island, tests astronaut's emergency escape system.

Nov. 5—Explosion in upper compartment of X-15's lower rocket engine shortly after drop from B-52. Landed safely.

Nov. 7 — Discoverer VII fired into polar orbit. Recovery by C-119's fails.

Nov. 10 — Five-stage rocket, dubbed "Strongarm," fired 1050 miles into space. Purpose: to measure electron density in ICBM environment between 500 and 875 miles.

Misco RIDES WITH THE X-15!
POWERPLANT USES
DOUBLE-V CASTINGS
One-piece Nozzle
Two rotor blade segments, one with two blades, and one with three blades, produced by Misco's DOUBLE-V (Vacuum Melt and Vacuum Cast) System, of Udimet 500; and a one-piece cast nozzle of stainless steel, — are used in the turbo-pump of the X-15 powerplant. These castings were supplied to Reaction Motors Division of Thiokol Chemical Corporation.
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MEGABOOM BUILD-UP

solid propellant rocket for test sleds is assembled at Astrodyne Inc. which has since become Rocketdyne's Solid Propulsion Operations.

COLLIER TROPHY

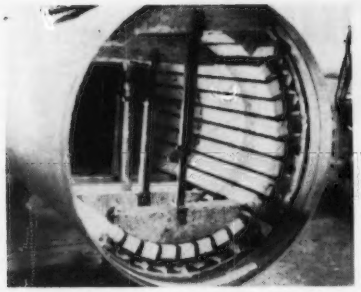
The annual Collier Trophy will be awarded December 17 to the Air Force-industry team responsible for the F-104 interceptor.

Honors go to: Clarence L. Johnson of Lockheed Aircraft Corp., design of the airframe; Neil Burgess and Gerhard Neumann of the Flight Propulsion Division, General Electric Co., development of its J79 turbojet engine; Lt. Col. Howard C. Johnson, USAF., for establishing a world land-plane altitude record of 91,243 feet; and Major Walter W. Irwin, USAF., for establishing a world straight-away speed record of 1404.09 miles per hour.

The trophy is given by Look Magazine and the National Aeronautic Asso. for "the greatest achievement in aviation in America • • • during the preceding year."

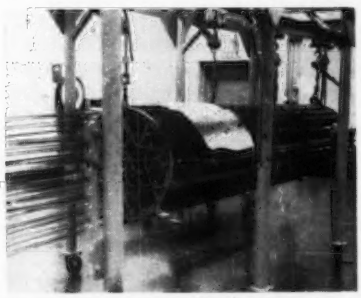
EMPLOYMENT

Department of Labor's "Manpower in Missiles and Aircraft Production" estimates that 350,000 workers were producing missiles and missile components as of April '59; at least 125,600 of them were in aircraft plants; some 67,400 missile workers were in the "ordnance and accessories" group; some 57,000 in the communication equipment industry. Thirty-eight per cent of the 320 establishments (surveyed in the last quarter of '58) reported shortages of engineers.



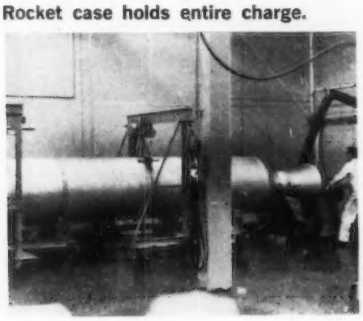
Cog grains are cemented to inner wall of Megaboom case in four banks. Each grain burns along two sides.

Propellant charge, in this case tri-form shaped, is slipped on its three longitudinal steel rods.



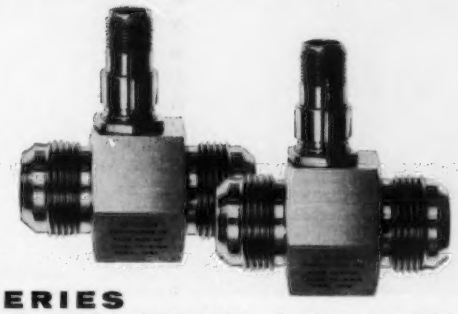
One of four propellant "bundles." Plates between bundles support the rods, provide alignment in case.

Rocket case holds entire charge.



Waugh FLOW SENSORS . . .

a significant advance in flow instrumentation



FF SERIES FLUID BEARING

FB SERIES BALL BEARING

The new Waugh FF and FB Series flow sensors are an outgrowth of more than 25 years experience in the design and production of flow instrumentation. Completely new, yet proven through strenuous testing in actual use, these flow sensors have almost universal application and are the basis for our standard flow instrumentation line.

Both models feature extremely high accuracy, linearity and *infinite* life in use. Decreased bearing drag aids to linearity and practically eliminates maintenance problems.

The turbine rotor of the FF sensor floats entirely on a filtered film of the liquid being measured, obviating wear from either radial or thrust friction. The FB turbine is supported by two ball bearings, which are lubricated and scavenged by the fluid in the line.

FLUIDS — Meters hydraulic oils, cryogenics, corrosive fluids, jet-aircraft fuels, and many other difficult to handle fluids.

LINEARITY — ± ¼%.

REPEATABILITY — The absence of conventional bearing surfaces results in reproducability within 0.1% of flow rate.

EXPECTED LIFE — Infinite.

SIZES and FLOW RANGES — Standard ranges are from 2 to 500 GPM, in sizes from ⅜" to 2¼" line o.d. The FB series is available also in ½" line o.d. model with flow range from 1 GPM. Standard models available in bulkhead length. Other sizes and ranges are available.

LINE PRESSURE — Standard stainless steel unit is suitable for 5000 psi, with higher pressure ratings available.

This FF Series sensor has been operating **continuously** at 35 GPM for 5609 hours to date, and is still functioning perfectly. Expectancy unlimited!

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Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster® Patented, No. 2,523,936 by IDEAL

IDEAL INDUSTRIES, Inc.
1390-L Park Avenue, Sycamore, Ill.
Gentlemen: Please send catalog information on IDEAL's New "Custom Stripmaster."
Name_____
Company_____
Address_____
City_____ Zone____ State_____

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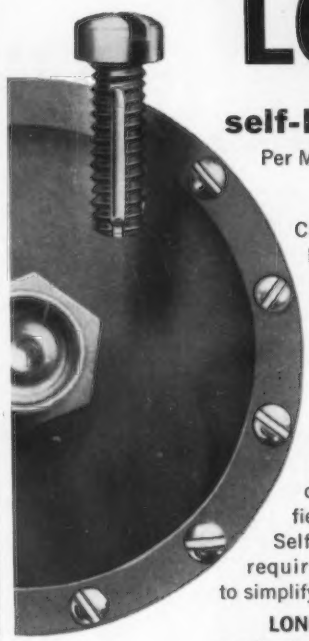
eliminate safety wire

on airborne accessories with...

LONG-LOK



self-locking screws

Per MIL-F-18240

Critical **weights** and needless and costly man-hours of **assembly time** are being saved through the use of **LONG-LOK** Self-Locking Screws on pressure switches, motors, pumps, valves and other airborne accessories.

Many companies in the aircraft, missile and rocket fields are using **LONG-LOK** Self-Locking Screws per the requirements of MIL-F-18240 to simplify their assemblies.

LONG-LOK Self-Locking Screws are heat, vibration, shock and impact resistant. They are reuseable and can be head marked for self-lock identification per specification. Increased reliability of component **and** system is assured.

LONG-LOK Self-Locking Screws are solving new fastener problems every day. They could be the answer to your needs.

Write for Catalog LL-59.

LONG-LOK CORPORATION

2601 COLORADO AVENUE • SANTA MONICA, CALIFORNIA

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PRODUCTION TECHNIQUES

Nuclear measuring devices are proving useful for maintaining uniform thickness of tire cord fabric. **Goodyear Tire & Rubber** passes beta rays through the cord, then measures exact dimensions.

Seventy-five per cent reduction in deburring time is claimed from **cutting-deburring tool** developed at Boeing-Wichita for aluminum sheets and extrusions from 1/32 to ¼ of an inch thick. It is produced under license by Aircraft Tools Inc., Los Angeles.

Cornell University reports it can now predict, through a full range of conditions, the distribution of liquid fuel used as a **coolant in rocket nozzles.**

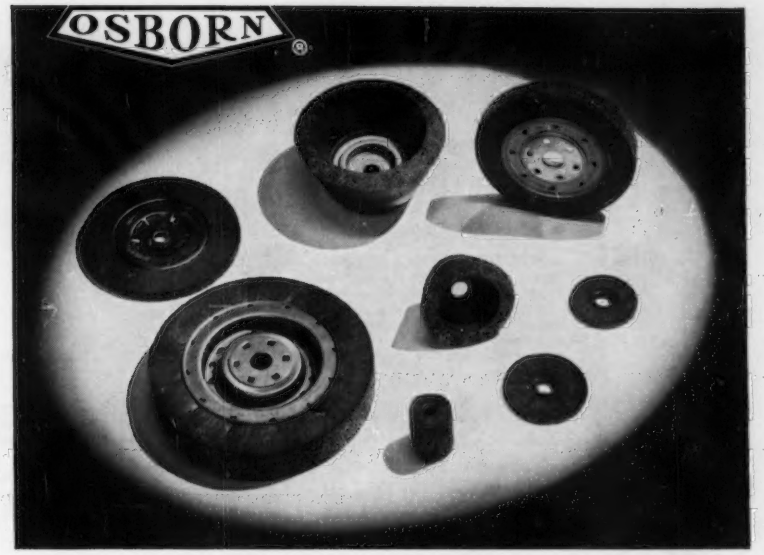
Martin engineers, Harold Barr and Donald Peterson, won $1,000 from the Nuclear Div. for method of **reducing abrasion in liquid fluidized bed reactor** by adding powdered graphite to water separating pellets of fissionable fuel.

Scientists at Battelle Memorial Institute say that use of a water-cooled copper crucible for **induction melting reactive metals** is technically feasible.

Boeing-Wichita has designed five lb portable current-path verifier for **electrical checking** during aircraft assembly and modification.

Hughes Aircraft reports a process for **casting optical-quality silicon** for use in military weapon system infrared sensors. Molds are designed to approximate shape of the finished part.

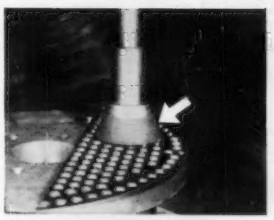
Full-scale mockup of Aerojet-General's concept of one-to-two-million-lb-thrust engine.



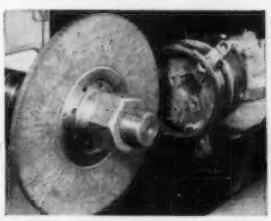
Here's how

JOB-PROVED TY® BRUSHES

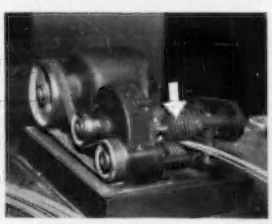
are cutting metal-finishing costs across the board



Application: deburring



Application: Surface finishing



Application: wire insulation stripping

In use today on a wide range of applications —Osborn TY® Tool Brushes are *engineered to cut finishing costs.* New TY Brushes are designed for jobs *beyond the reach* of standard wire power brushes.

Where rotary files, abrasive stones or belts, tumbling and shot blasting equipment have been used—TY Brushing Methods now do many of these jobs better and faster . . . at significantly less cost.

Do you know which operations in *your plant* can be done at high production rates . . . with better quality control . . . at less cost with new TY Brushes? An **O**sborn **B**rushing **A**nalysis—made in your plant now at no cost—is the first step. Write for full details.

Exclusive TY Brush advantages performance proved on-the-job:

- Maximum of work efficiency with minimum of pressure.
- Greatly increased brushing action strength.
- Positive control over area of brush contact.
- Complete uniformity of finish.
- Exceptionally long brushing tool life.

Write For Free TY® Brush Booklet... complete, illustrated application and specification data for production men. *The Osborn Manufacturing Company, Dept. AM-7, Cleveland 14, Ohio.*

Osborn Brushes

POWER, PAINT AND MAINTENANCE BRUSHES
METAL FINISHING MACHINES...AND FINISHING METHODS
FOUNDRY PRODUCTION MACHINERY

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DO YOU NEED PARTS REQUIRING FINE MACHINE WORK SUCH AS THIS FACE CLUTCH?

ACTUAL SIZE

SPECIFICATIONS:
Material: Type # 303 Stainless Steel
300 90° "V" teeth, equally spaced
Teeth .0092-.0005 deep
Face runout of top of teeth not to exceed .0005TIR
Completely burr free

This is the class of work which has been the specialty of LaVezzi for over 50 years. Your critical machine parts can be produced efficiently and correctly by LaVezzi, and your quote requests are eagerly solicited. Facilities list and brochure upon request.

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American Beauty...an iron for every Soldering Job

Whatever your soldering problem, American Beauty has the right iron for your particular job. The finest engineering, best materials and on-the-job experience since 1894 is yours with EVERY American Beauty. There is a right model, correct tip size (¼" to 1⅛") and proper watt-input (30 to 550 watts) to do any soldering job. Ask about which iron will do your job best. American Beauty electric soldering irons are the highest quality made.

ILLUSTRATED IS CATALOG NO. 3125
¼" TIP SIZE, 60 WATTS

TEMPERATURE REGULATING STANDS
Automatic devices for controlling tip-temperature while iron is at rest—prevent overheating of iron, eliminate frequent retinning of tip, while maintaining any desired temperature. Available with heavy-gauge perforated steel guard—protects user's hand.

YOU CAN'T BEAT A SOLDERED CONNECTION

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WRITE FOR 28-PAGE ILLUSTRATED CATALOG CONTAINING FULL INFORMATION ON OUR COMPLETE LINE OF ELECTRIC SOLDERING IRONS—INCLUDING THEIR USE AND CARE.

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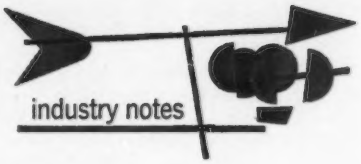
American Beauty ELECTRIC IRONS SINCE 1894



FACILITIES . . .

Marquardt Corp. plans to complete its Van Nuys laboratory for nuclear and high temperature materials research by late 1960. Both Power Systems Group and Pomona Div. are also slated to have new engineering-administration building next year. Marquardt's newly established Nuclear Systems Div. now has primary initial responsibility for the firm's propulsion system work.

Armco Steel Corp. plants to add 69,000 sq ft to Middletown, Ohio, Research Center. It will include a laboratory for nuclear studies where radioactive isotopes will be used extensively.

Johnston & Funk Metallurgical Corp. has moved headquarters and plant to Huntsville, Ala.

First stages of a multimillion dollar expansion in r & d facilities plus a propellant research program are being activated by the **Grand Central Rocket Co.**

General Mills, Inc., has acquired the business and assets of **Magnaflux Corp.** and plans to expand latter's non-destructive-testing line.

The Army Ordnance Missile Command's newest facility at Cape Canaveral, Fla., is a blockhouse and launch complex for firing and tracking Pershing.

Texas Instruments Inc. has established a Nuclear Development Dept. of its Central Research Laboratory, Attleboro, Mass., to accelerate development of advanced nuclear fuels.

Westinghouse Electric Corp. is opening a new facility to house a Nuclear Components Development Laboratory at Cheswick, Pa. It will be used for evaluation programs, pilot and full production on nuclear fuels and materials.

Advanced Materials Div. just established at **Taylor Fibre Co.** will develop laminated plastics and vulcanized fibre for missiles, jet aircraft, and nuclear reactors.

New research section at **Convair-Fort Worth** will concentrate initially on the environments and conditions which will surround space vehicles.

TA "King-Size" Instrument Cases 4 PAGES

TA Standard Instrument Cases 20 PAGES

Learn how TA's new predesigned Instrument Cases solve *your* equipment housing problems.

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THESE EXCLUSIVE FEATURES—STANDARD WITH TA—SAVE YOU TIME AND COST

1. Predesigned panel-layouts for perfect fit.
2. Large selection of standard sizes and styles.
3. Wide choice of standard handles, access doors, panels, and other accessories.
4. All standard Cases include panel gaskets.
5. All Cases protected by air relief valves.
6. Available in depths from 2½ to 18 inches.
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9. Precision quality.
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TA Cases come in a diversity of standard lid sizes, and are sold at proprietary prices. During assembly the depth can be cut to your exact specifications. Or, if you like, TA will furnish you free vellums and templates so you can save yourself money by designing your product to fit one of the many standard sizes.

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This new procedure has solved hitherto unsolvable problems, and greatly increased capacity and quality in virtually every application.

As pioneers in this very "young" development, we can offer you real help in licking hard metal removal problems, with actual installation and performance data. **WRITE TODAY!**

Results depend on the spindle used. There is nothing finer in its field than a STANDARD Super Precision Spindle . . . available for electrolytic application in 50 to 3000 Amperes.

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Precision Spindle Division
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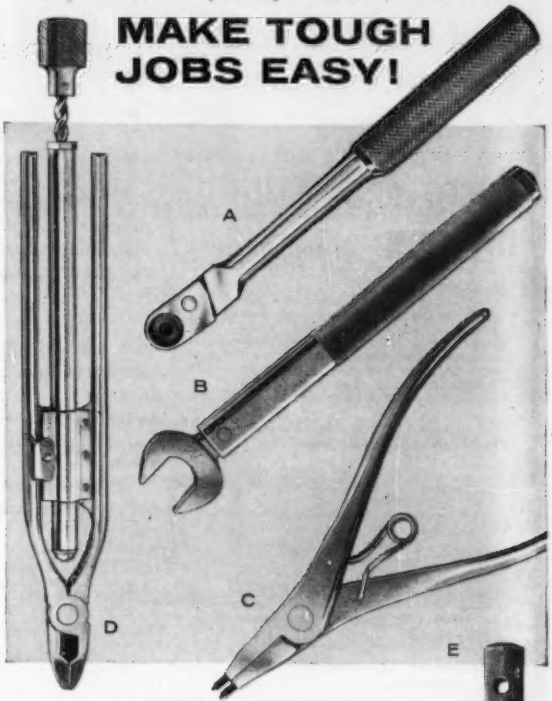
MILBAR

special purpose tools

MAKE TOUGH JOBS EASY!



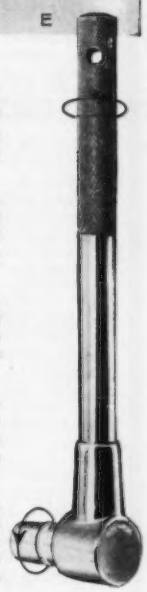
A. MILBAR CLOSE-CLEARANCE RATCHET WRENCH for tightening or removing twelve-point or hex-head screws and nuts. Fits in the tight spots where regular wrenches won't work. Smooth ratchet action. Several sizes available. Widely used in aircraft and missile industries.

B. MILBAR SNAP TORQUE TOOL—with pre-set torque. A "click" you can feel and hear tells when proper torque is reached. A choice of head types for specific jobs. Widely used on production lines in the automotive and aircraft industries.

C. MILBAR SNAP RING TOOL—the original and most widely used tool with replaceable points of different shapes and sizes. Tool lasts forever—just change points for the job at hand or when they wear out. Special points for holeless snap rings.

D. MILBAR WIRE TWISTER—for smooth, automatic one-hand operation. Extra large serrated jaws assure a longer life and non-slip grip. Spring return and squeeze release eliminates need for shifting hands. Twists and cuts wires with no waste motion.

E. MILBAR GEARED RIGHT-ANGLE TOOL—for easy access to "tight" spots. Fits all standard ⅜" drive extensions, sockets and ratchets. Reaches around corners and delivers increased torque for tightening or removal. Eliminates unnecessary removal of parts to get at the job to be done. Fully proven and tested by thousands of users.



Send for your free brochure describing these, and other, MILBAR Special Purpose Hand Tools. MILBAR has the engineering facilities and personnel to solve your special problems where sufficient volume is involved.

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1900 EUCLID AVENUE • CLEVELAND 15, OHIO

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FLIGHT PROPULSION DIVISION

GENERAL ELECTRIC

Cincinnati 15, Ohio

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industry notes

MATERIALS OUTLOOK

The R&D department of the Bridgeport Brass Co. is working with the Aircraft Nuclear Propulsion Division of General Electric on **hot extrusion of yttrium metal and its alloys.** This work is part of a larger program to produce precision complex components of exotic metals for an airborne nuclear propulsion system.

Pourable rubber-based material for **shielding crew and passengers from neutrons** produced in nuclear-powered aircraft has been developed by the Goodyear Tire & Rubber Co. Castable, it can be used to overcome the fabrication problems encountered when slabs of rigid polyethylene are used for neutron shielding.

Titanium Metals Corp. of America cites use of **titanium** for the fourth-stage motor casing in the Juno II rocket as saving two lb. in payload weight. Alloy was Ti-6AL4V.

U. S. Nuclear Corp. made a 7,000 lb. stainless steel, lead-filled **fuel elements cask** to house radioactive materials at an overseas installation.

Mallory 1000 high density metal is now available in spheres which make **forming of shields for radioactive materials** possible at the site without machining or fitting.

Pratt & Whitney Aircraft is using **Elcide 75 treated coolant** in 624 machines of their East Hartford plant.

A new coating preventing scale formation on metal during heat treatment was announced by Los Angeles Div., North American Aviation. Applications include the new exotic alloys now under development. Tradename: "Skalix."

Hovolite, a new **low-density nonwoven filter material** developed by Hollingsworth & Vose Co., is being used for filtering radioactive dust in atomic energy installations.

Mobay Chemical Co. says new **urethane elastomer developments** result in an engineering material outperforming conventional rubber by a factor as high as 800 to 1.

BALLYMORE
"Hi-boy" LADDERS

have exclusive PYRAMID design and automatic BALLYLOCK floor locking

ALL-WELDED STEEL FOR REACHING HEIGHTS UP TO 15 FEET

For complete information, write:
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WEST CHESTER 27, PA.

BALLYMORE
EQUIPMENT FOR ABOVE-FLOOR SAFETY

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industry orbit . . . continued

Div. have reportedly developed lightweight high frequency turbine propelled by hot liquid potassium (290 PSIG); it's intended for satellite control.

PRODUCTION

Beryllium reportedly is finding special application in shrouding of warhead sections for hydrogen weapon ballistic missiles. Polaris uses unprotected beryllium sheet. Later weapons, such as Minuteman, reportedly will use stainless over beryllium. . . . Heat sink vs. ablative plastic competition for Mercury shielding has not been openly resolved. At least eight heat sinks are expected to be produced by Brush Beryllium and eight ablative cones by General Electric and B. F. Goodrich. . . . Lox manifolds for the Saturn super-booster have been made by Olin Mathieson, using explosive forming on aluminum alloy 5052-T-32 to produce finished product 0.188 in. thick.

PROCUREMENT

Military and space strategists have been working out their requests for the next fiscal year. Proposed budget goes to Congress next month. The administration has declared it can be no larger than last year's $41-billion. Service slices of the present budget are Air Force 45 per cent; Navy 28 per cent; Army 23 per cent . . . Defense Department now has single comprehensive set of cost principles for use in defense contracting. Rules now provide common guide lines for negotiated fixed price type contracts. Copies available U. S. Government Printing Office, Washington 25, D. C. ($.35).

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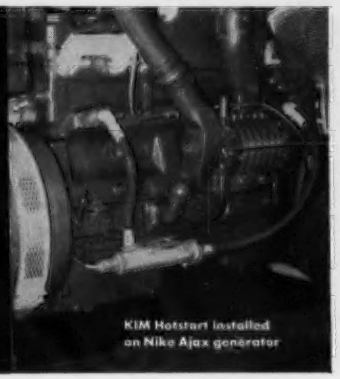
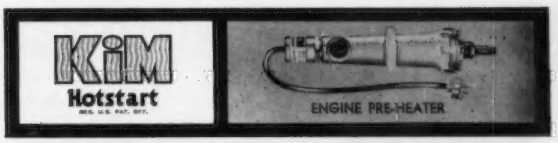
KIM HOTSTARTS keep U. S. NIKE AJAX on all-weather ALERT!



When efficiency is measured in split seconds, "cold starts" must be eliminated. That's why Nike Ajax are now equipped with KIM Hotstart engine pre-heaters. Regardless of weather, they enable operation under full load within seconds. For details on KIM Hotstarts, see your automotive dealer or write us for free literature.



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PRECISION CONTROLS
Specified for
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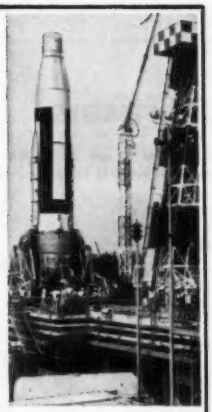
Superior facilities, experience—plus prompt deliveries—have built confidence in Kohler precision controls for aircraft, automotive and industrial installations. Our engineers develop controls to specifications for volume production. Write for information.



CHECK VALVES:

Connections:
MS-33514 Flareless tube and gasket seal
MS-24385 Flared tube and gasket seal

Operating Pressure:
1500 PSI and 3000 PSI

Proof Pressure:
2250 PSI and 4500 PSI

Burst Pressure:
4500 PSI and 7500 PSI

Temperature Range:
−65° F to 275° F

Material:
1500 PSI Aluminum
3000 PSI Stainless Steel

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KOHLER OF KOHLER
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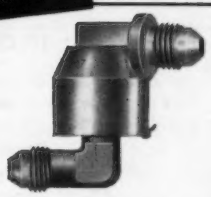
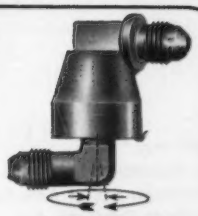
NOW AIRCRAFT TYPE SWIVEL JOINTS



LOW TORQUE PLANE SWIVEL JOINT—
360° rotation in a single fixed plane.



NEW SELF-ALIGNING SWIVEL JOINT—
360° rotation *plus* 15° side flexibility.

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Here are the newest designs in the field! SEND TODAY FOR BARCO CATALOG 269A. Since 1941 Barco Swivel Joints and special Flexible Assemblies have met the precise requirements of in-flight and other types of military equipment . . . *conforming to MIL-J-5513A and other specifications.* Barco's wide experience is yours to call upon in the development of your particular project—aircraft, missile, track vehicle or special installation—for hydraulic, pneumatic, oxygen, fuel, gas or liquid service. Barco Representatives are at your service in the specification of standard or specialized adaptations of standard designs.

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your date book

november 30-december 4
annual meeting
american society of mechanical engineers
chalfonte-haddon hall hotel, atlantic city

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december 1-3
eastern joint computer conference
IRE, AIEE, ACM
statler hilton hotel, boston

◆

december 2
annual industrial preparedness meeting
american ordnance association
waldorf-astoria, n.y.c.

◆

december 6-9
52nd annual meeting
american institute of chemical engineers
sheraton-palace hotel, san francisco

december 7-11
national conference on the application of electrical insulation
AIEE, national electrical manufacturers assn.
sheraton-park hotel, washington, d.c.

◆

december 8-9
aerospace finishing symposium
society of aircraft materials and process engineers,
american electroplaters society
hotel texas, fort worth

◆

december 10-11
technical symposium and product exhibition
New York chapter, institute of environmental sciences
henry hudson hotel, n.y.c., n.y.

◆

december 17
23rd Wright Brothers lecture
natural history bldg.,
smithsonian institution
washington, d.c.
Dr. Alexander H. Flax will speak on high temperatures in hypersonic flow

◆

january 11-13
sixth national symposium on reliability and quality control in electronics
statler-hilton hotel, washington, d.c.

◆

january 12-16
annual technical conference
society of plastics engineers
conrad hilton hotel, chicago

◆

january 14-20
sixth annual meeting
american astronautical society
statler-hilton hotel, n.y.c., n.y.

◆

january 25-28
annual meeting
institute of the aeronautical sciences
hotel astor, n.y.c., n.y.

◆

april 4-7
1960 nuclear congress and exposition
the coliseum, n.y.c., n.y.
Subject: "What will the future development of nuclear energy demand from engineers?"

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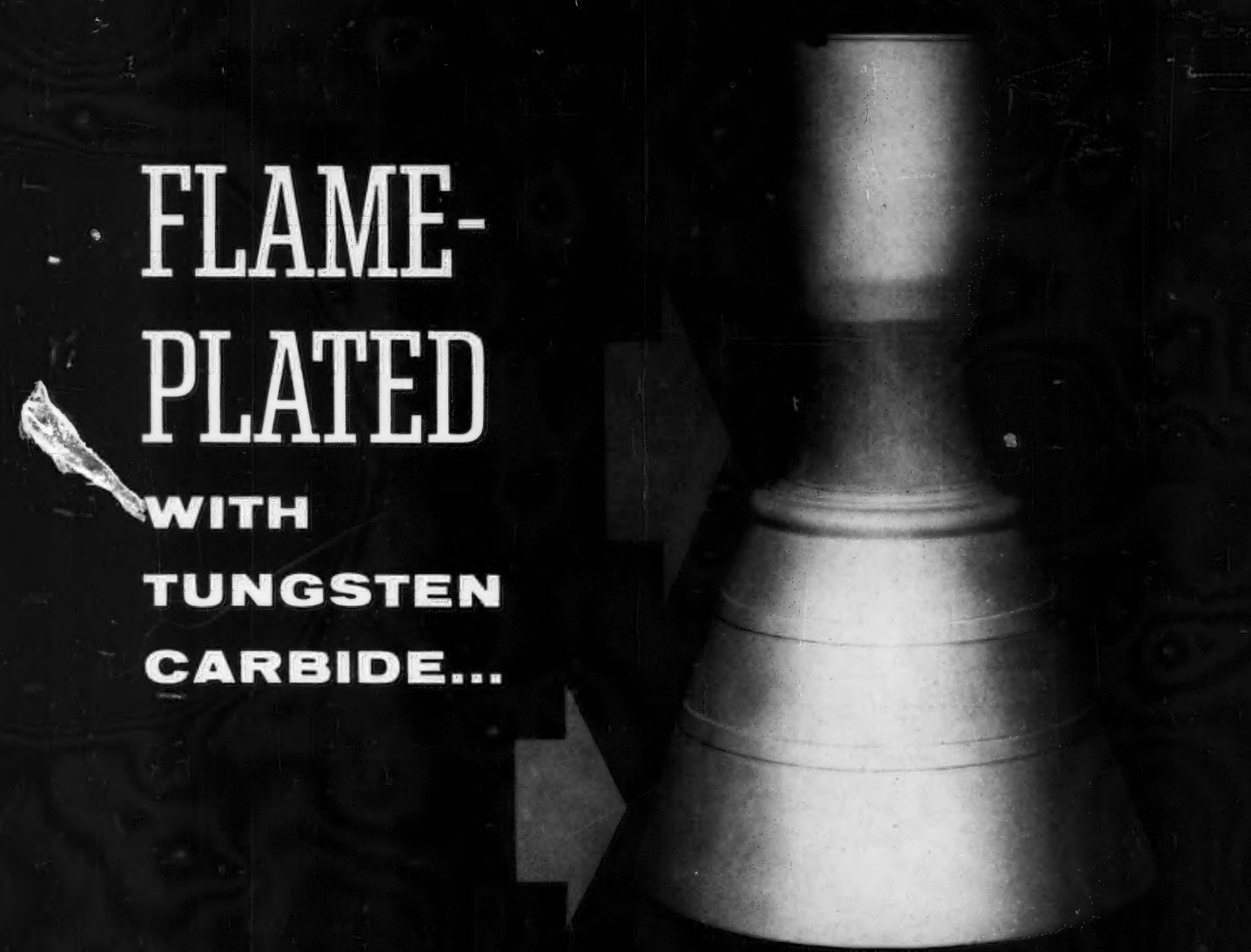

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